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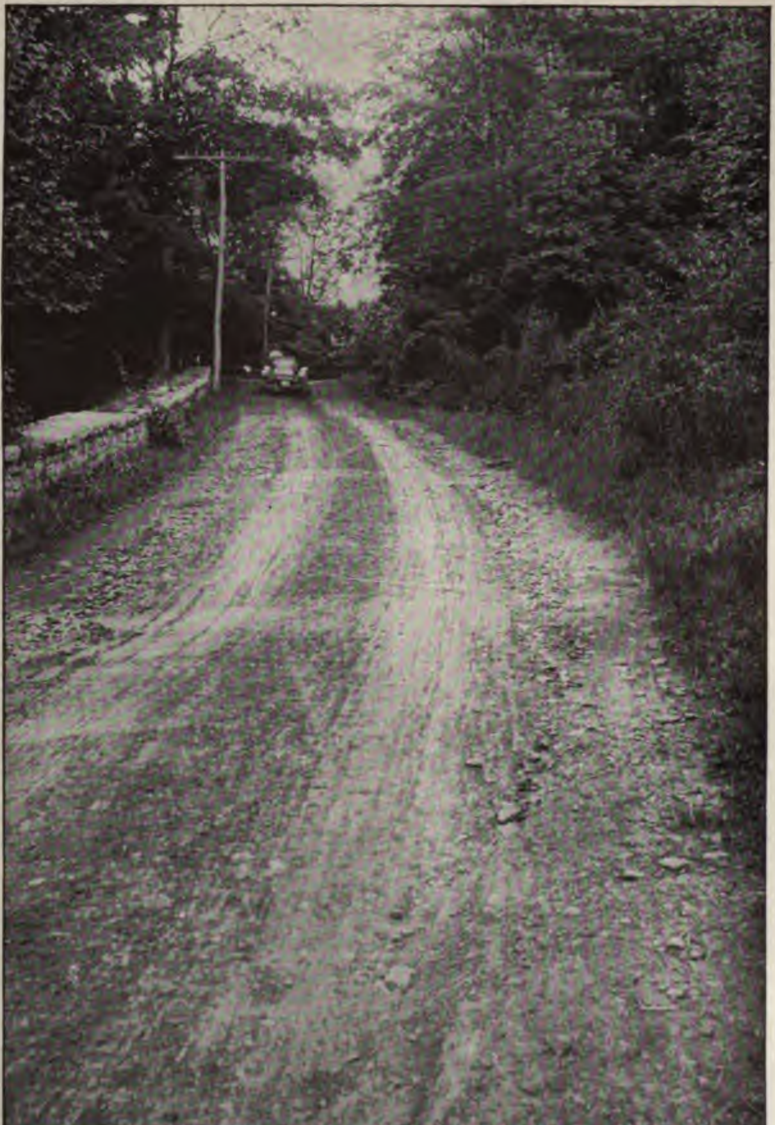

A New England Road.

VOLUME THREE

The AMERICAN CYCLOPEDIA *of the* AUTOMOBILE

or, MOTOR CARS *and* MOTORING SELF-TAUGHT

A WORK OF REFERENCE & SELF INSTRUCTION, COVERING the ENTIRE FIELD OF AUTOMOBILING. FOR OWNERS, REPAIR MEN, OPERATORS, INTENDING PURCHASERS & ALL OTHERS INTERESTED IN MOTORING OR the AUTOMOBILE TRADE

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Complete in Six Volumes

.... BY ....

THOMAS H. RUSSELL, LL. B., M. E.

: : AND : :

CHARLES P. ROOT, former Editor of *Motor Age*

Assisted by a Corps of Experts

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end to end, so that the valve opens to its maximum when one limit of the cam is beneath the plunger which acts on the valve stem, and the valve lift is at its minimum when the other limit is reached. In some cases the sliding motion of this sleeve is attained by connecting the sleeve with the governor, with the result that the lift of the valve depends on the speed of the engine, and consequently the amount of mixture admitted to the combustion chamber is regulated according to the work to be done. In this system the compression is reduced in proportion as the lift of the valve is reduced, but in no case to a serious extent.

One of the greatest advantages of this system consists in the fact that the errors in the ordinary governing device can be corrected. We have already pointed out that "hunting" is a common fault with the ordinary centrifugal governor, and fully described the meaning of the term. Where a sliding shaft carrying tapered cams is used, as above described, for regulating the lift of the valve, the irregularity in the action of the centrifugal governor can be, to a great extent, compensated for by decreasing the difference in diameter of these tapered cams over certain portions of their profiles. This has the effect of making the decrease in the lift of the valve, between any two speeds of the engine with a common difference, constant.

In some systems of governing methods (a) and (c) are combined. That is to say, a throttle valve is worked by the governor, and a hand-operated lever controls the movement of a sliding shaft, which carries the tapered cams by means of which the lift is varied. In this case, however, the cams instead of being fixed on a sliding sleeve, are made solid with the shaft, which is itself capable of lateral movement.

Again, another variation is to be found in certain types. There is no mechanical governor. For controlling the speed of the engine the throttle is normally operated by hand; but there is also a sliding shaft—carrying tapered cams—controlled by a pedal, which when operated reduces the compression, and when the pedal is pushed right home prevents the inlet valves from opening and causes the exhaust valves to open on each down stroke of the piston, thus turning the engine into an air compressor affording a powerful brake.

(d) By Reducing the Time of Opening of the Inlet Valve—In this system there is a special device for directly varying the time of opening of the inlet valve. It affects both the opening and the shutting of the valve, and its action approximates to the cut-off of a steam engine. Needless to say, it curtails the volume of gas in the cylinder, so that the compression is reduced

None of these varied systems are absolutely perfect. In the opinion of well-known authorities on gas engine design, the ideal arrangement would be to have a small quantity of perfect mixture round the ignition points, while the rest of the charge required to provide the normal compression should be simply air. The operation of the governor would vary the quantity of mixture admitted, in addition to this air.

Governing and Control—In addition to the means provided for controlling the speed and power of the motor by hand, many cars are fitted with an automatic governor. This generally takes its action from two balls or weights linked to one of the revolving spindles of the motor, and also linked to a collar or sleeve sliding on the same spindle. The weights are normally held close in to the spindle by springs, but as the speed of rotation increases, the weights fly outward more or less, and in so doing move the collar lengthwise. The collar is generally connected to the throttle, so that when a certain speed is reached the governor begins to cut down the supply of gas. This slows the motor, the weights return inward, the collar moves back, and the throttle is again opened, so that the motor picks up its speed once more. When these changes keep repeating the governor is said to "hunt," and it shows that it is badly designed. See under Governing above. A governor that works properly finds and preserves an even balance of the different parts affected.

Some governors are adapted to act on the valve gear so as to modify the operation of the valves. Thus, the governor may control the motor by cutting out the lifting mechanism of one or more of the exhaust valves; or by varying the lift of the inlet or of the exhaust valves. The cams on the half-speed shaft may be taper, and the shaft itself movable lengthwise by the governor in order to produce this last action.

The governor may be adjusted to operate at higher or lower speeds by altering the tension of the springs or by other means. The governor is also generally controllable by an "accelerator pedal," the depression of which puts the governor temporarily out of action, and allows the motor to develop its full power. The governor is particularly useful for preventing the engine "racing" at such times as, owing to the exigencies of traffic or otherwise, the driver declutches, that is, disconnects the motor from the driving gear. If no governor be fitted, the clutch pedal should be coupled up to the throttle, so that the action of withdrawing the clutch automatically reduces the supply of gas to the engine.

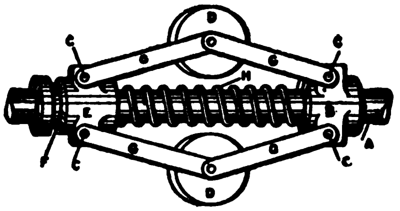
Steering Wheel Control.

In all cars, whether there is a governor or not, the driver is given control over the motor by hand or foot connections leading to the throttle, and, as a rule, to the spark-timing apparatus; sometimes he has hand or foot control of the lift of the exhaust or inlet valves. It is now common practice to mount the throttle lever, and very often the sparking lever, on the top of the steering wheel, so that the speed and power may be regulated without the driver releasing his hold of the wheel. In some cases the levers move with the wheel, and in others they do not. There are advantages attaching to each arrangement, but the better arrangement is levers which do not work with the wheels. The wheel-control idea is being well developed, one modification consisting in making two sections of the rim of the steering wheel to rotate on the circumferential axis. The connections are taken down inside the steering column, and thence to the engine. The switch also is now often mounted on the steering wheel. In the less elaborate cars the sparking, throttle, and also the mixture are frequently controlled by small levers pivoted on the steering column just below the wheel. It is a convenience at first if the levers are impressed with names indicating their office, thus: "Throttle," "Gas," "Spark," and with directions for moving them, such as "Open," "Closed"; "Air," "Gas," and "Advance," "Retard," respectively. They should always be provided with finely-cut racks or other devices for retaining the levers or handles wherever they are set. It leads to needless worry and expense, for example, if the throttle lever is always working to the full open position, while the sparking lever persistently subsides to dead slow.

Governor—Owing to the fact that an internal combustion engine gives its greatest efficiency for fuel consumed, at a definite and constant speed, it is necessary that some form of regulator should be adopted which will act on some part of the mechanism in such a way as to reduce the speed should it get too high, or cause it to increase should it fall too low. For this purpose the centrifugal force set in a weight moving in a circle is utilized, and the appliance is known as "the centrifugal governor." There are many types of these, but the principle in all is the same.

Our illustration shows diagrammatically the principle on which all these governors work.

In this illustration A is the shaft which is driven from the engine by gearing, and generally forms part of the two-to-one shaft operating the valves. On it is a fixed collar, B, which rotates with it, and which has two projecting ears or lugs, as shown. A similar collar E, also having projecting lugs on it, is free to slide up and down on the spindle A, and has at its left hand end a groove F. These two collars, E and B, are connected together by the links G, G, G, G. It will be seen that these links also connect two weights D, D hung at their center. When the shaft A is revolved the centrifugal force, acting on the weights D, D tends to throw them outward. This action would cause the collar E to approach the collar B, but its movements in that direction are controlled by the helical spring H, which is in compression between the two collars. When the centrifugal force balances the pressure of the spring, the collar E remains stationary on the shaft, but on any increase of speed in the rotation of the shaft A, the centrifugal force is increased, and, overcoming the resistance of the spring H, the weights fly outward, drawing the collar E along the shaft. By the movement of the collar E along the shaft, a motion can be given to a fork at the end of a lever and encircling groove F. This fork will give a motion to a lever, which can be transmitted in any suitable manner to the apparatus which is used to either cut off the fuel supply or operate the valves in such a manner as to decrease the power in the engine cylinder. The different methods of applying this movement in the governing of internal combustion engines are fully described under the heading Governing, but whatever method is adopted, the primary movement is generally brought about by a centrifugal governor acting practically on the principles of the one illustrated.



CENTRIFUGAL GOVERNOR

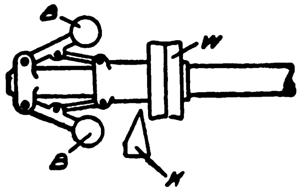
A, Shaft with which governor revolves.
B, Collar fixed to shaft A.
C, C, Pins which carry governor links.
D, D, Governor weights.
E, Collar sliding on shaft A.
F, Slot in which actuating fork runs.
G, G, G, G, Links carrying governor weights.
H, Controlling spring.

Another View of the Governor.

All explosion engines, and therefore gasolene car engines, have the drawback that when overloaded they stop. This is not the case (within much wider limits, at any rate) with steam or electric motors. The latter motor, like a willing horse, prefers to do itself an injury (to burst a blood vessel, as one might say) by burning out its coils with excess of current rather than stop.

The explosion engine keeps itself safe, but this, again, is a drawback in some ways. If a driver is not to be perpetually on the watch for overloading his engine at the slightest up grade it is clear that it must have a good margin of power when running on the level.

The maker must decide, therefore, that some predetermined small incline (let us say up to 1 in 30) shall be mastered by the car on its top gear, otherwise the unfortunate driver would be ceaselessly changing. It happens, however, that a grade of 1 in 30 takes nearly double the power required on the level at the same speed, so that on the level such an engine has always a large margin of superfluous strength, and is always inclined to "race." This racing is bad for the motor, which, therefore, is provided with a governor. On small cars, where the margin of power is not so large, racing is prevented by hand by (I.) retarding the ignition, (II.) partly closing the gas inlet, (III.) lifting the exhaust valve, (IV.) holding the exhaust valve intermittently down, and other devices. The governor on large cars generally effects either (II.), (III.) or (IV.) automatically. No. I is objectionable.



Hit-or-Miss Governor.

One device by which above a certain speed some movement essential to the drawing in of a charge of gas is prevented is the "hit-or-miss" governor—as in the figure.

The knife edge K may be made to rise and fall every time the exhaust valve is lifted. If, however, the speed is great enough to make the two fly balls B, B swing out they drag out with them the notch wheel W till it prevents the knife from descending, thus keeping the exhaust valve open.

At this particular speed the engine therefore fails to draw in a charge, and therefore fails to fire till the speed falls again. This is seldom used on cars, but it will some day be used more, because of its great fuel economy compared to the usual method of closing the throttle by means of a pair of flybobs which move a rod actuating the throttle.

Governor Balls—See Governor.

Governor, Function of the—See under Engines.

Governor, Hit-or-miss—See under Governor.

Governor, Pneumatic—A governing system which includes a reciprocating air pump, operating the piston of a small cylinder and thus regulating the lift of the inlet valve. Also known as Winton's Governor.

Governor Setting—See under Engines.

Governors: Their Use and Action—See under Engines; also Governing and Governor above.

Governors, Substitute for a—See under Driving.

Grade—A degree of ascent or descent in a road or railway, etc., either marked or slight; a gradient; also a portion of a road, either level or inclined. When two roads cross at the same level they are said to cross "at grade." "Up grade" and "down grade" are the ascent and descent respectively in a graded roadbed. "Grade crossing" is the term usually applied to the crossing of a railroad and a public highway at the same level. To grade land for highways or railroads is to reduce it to such levels or degrees of inclination as will suit the purposes of traffic. See Gradient.

Grade Indicator—An instrument for indicating the degree of grades or gradients. See Gradometer.

Grades, Coasting Down—See Coasting Slopes, under Driving.

Gradient—The degree or amount which the contour of a road varies from a horizontal line. It is often measured by expressing the ratio between the vertical height and the distance traversed. Thus, where in 14 feet of road surface traversed there is a vertical rise of 1 foot, the gradient is said to be 1 in 14. A gradient of 1 in 5 denotes that for every five feet of road there is a rise of 1 foot. It is more usual to express the grades in percentages. Thus, a grade of 1 in 5 is styled a 20 per cent grade. One in 10 is a 10 per cent grade.

Gradometer—An instrument which shows the gradient of the hill ascended or descended. It can be fixed to any convenient part of the car in a horizontal position. When the car stands on level ground the bubble should be at O. It is only reliable when perfectly adjusted and when weight is equally distributed on the car.

Gram or Gramme—The unit of mass in the metric system. It is theoretically the mass of a cubic centimeter of water at 4° Centigrade—the point of maximum density. Practically it is one-thousandth of a standard platinum kilogram kept in Paris, or 15.432 troy grains. See Metric System.

Gram-Centimeter—In physics, a unit of mechanical work; the work done when a weight of one gram is raised through the height of one centimeter against the force of gravity.

Gram-degree—The small calorie. See Calorie.

Graphite—An amorphous form of carbon which forms the basis of many dry lubricants. When ground and mixed with some binding substance, such as grease, etc., it forms an excellent lubricant for surfaces exposed to dust, as being dry the dust does not cling to it in the same way as it would to an oily surface. See Lubrication, under Repairs and Adjustments.

Asbestos or fiber packing, used between joints subject to heat, is prevented from sticking to the joint by having graphite rubbed into the faces. This in no way affects the joint. It is also useful for rubbing on the screws of bolts, nuts, etc., to render them easy of removal.

Graphite is also known as plumbago, and the coarser kinds as blacklead.

It has an iron-gray color, metallic luster, granular texture, and is soft and unctuous to the touch. It is used in the manufacture of pencils, crucibles and portable furnaces, for burnishing iron to protect it from rust, and in innumerable ways for counteracting friction between the rubbing surfaces of wood or metal in machinery.

Graphite, Artificial—Same as Gas Carbon.

Graphite for Chains—Graphite and graphite preparations are excellent for use in cleaning and preserving the life of chains. See under Cleaning, etc.

Graphite on Rims—See under Useful Information.

Graphite on Threads—See under Useful Information.

Grasshopper Springs—The technical name for semi-elliptical springs, such as are used on carriages and motor cars to absorb the road vibrations. See Springs.

Grate Surface—The area of any grate in a furnace. In a locomotive boiler one square foot of grate surface is supposed to suffice for the evaporation of eight cubic feet of water per hour.

Gravitation—A force by virtue of which every particle of matter tends to approach every other particle in the universe.

Newton's law of gravitation is that every body or portion of matter attracts and is attracted directly as its quantity of matter and inversely as the square of its distance from the attracting body.

Gravity—The accelerating force exerted upon any falling mass by the earth's attraction; also the property of weight as distinguished from mass. In physics, terrestrial gravitation; the force which draws everything toward the center of mass of the earth.

Specific Gravity is the ratio between the weight of a body and the weight of an equal volume of the recognized standard.

Gravity, Center of—The point about which all the parts of a body exactly balance each other, so that when that point is supported the whole body is supported.

Gravity, Specific of Gasolene—The specific gravity of gasolene should be about .680 or .682. See under Gasolene.

Gravity Feed—If the tank for gasolene or lubricating oil is above the level of the point where it is consumed and if the liquid is allowed to flow down to that level by its own weight, it is said to be "gravity-fed" in contradistinction to those arrangements in which the storage tank is placed at a low level on the car for convenience or compactness of design and the fluid is raised to the necessary height for its utilization by some pumping device which is said to be "pressure fed." See Lubricators.

Grease—A thick oil made especially for certain parts of motor mechanism. It is more suitable for lubricating bearings and gearing, which have heavy work to do, than ordinary lubricating oil, the latter not having sufficient body or viscosity in it. Good motor grease usually has a yellow color with a green tinge in it. It is used in the crankshaft and countershaft bearings, also in the bevel gearing and in the live axle. See Lubrication.

Grease Cock—See under Cock.

Grease Cup or Box—A box containing grease and fitted with a telescopic cover. By screwing down the cover, a portion of the contents is injected into the part or bearing connected with the cup.

Grease, Effect of on Rubber—See Destructive Effect of Grease, under Tires and Wheels.

Grease Gun—A device for the injection of grease into bearings, etc.; usually a form of screw syringe.

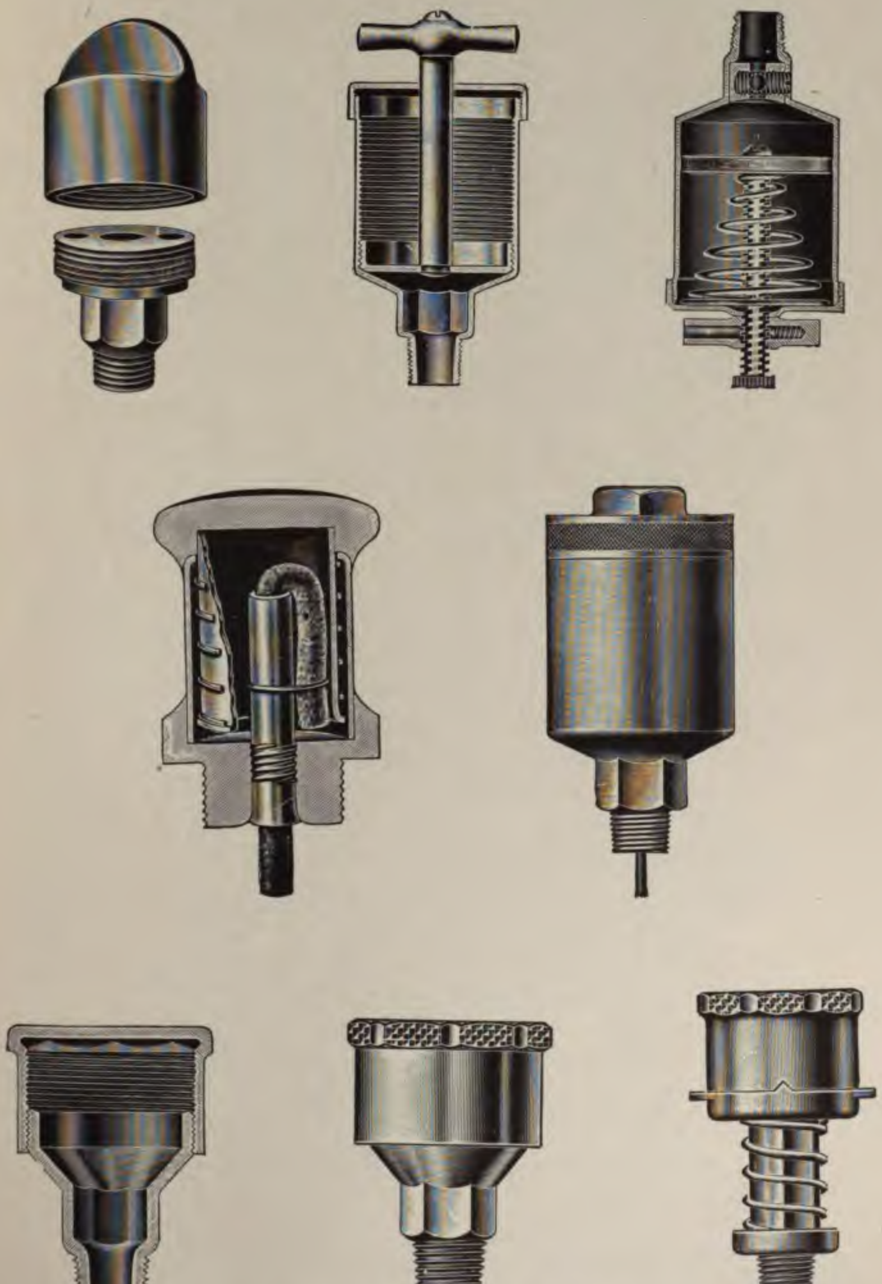
Grease Injection—See under Lubrication.

Grease Lubricators, Care of—See under Lubrication.

Grease Pump—An injector for forcing grease into a bearing, etc.; a grease gun.

Greasy Roads, Driving on—See under Driving.

Grid—In electricity, a zinc plate more or less resembling a gridiron, in a primary battery, or a lead plate with holes, corrugations or other means of support for the active matter of a secondary or storage battery. See Battery.



Empress Grease and Oil Cups—Bowen Mfg. Co., Auburn, N. Y.

UNIV. OF MICH.

Grinding In—See Valve Grinding, under Involuntary Stops; also under Repairs and Adjustments, Overhauling, etc.

Grinding Powder—A powder consisting mostly of emery or corundum, used for grinding in valves.

Grinding Valves—This operation is required to produce a gas-tight joint between the valve and its seat, as any leak at this point prevents good compression. See Repairs and Adjustments.

Gripping—The act of seizing or sticking, as a piston in a cylinder.

Ground—In electricity, to connect with the earth, as to ground a wire. See Earth or Ground.

Ground at the Timer—See Missing Explosions.

Grounding-wire, Extra—See under Ignition.

Ground-wire Connection—See Earth or Ground Wire Connection.

Grub Screw—A small headless set-screw, when flush with the surface, is called a grub screw. See Bolts and Nuts.

Guards—The projecting wings which are placed over the road wheels to protect the car and its passengers from the mud and dirt thrown up by the wheels. Also termed mudguards, wings or splashers.

Chains, gears and other mechanisms are provided with guards to prevent other objects becoming entangled with them.

Gudgeon—A term which applies to one type of those joints which oscillate but do not move. See Pins.

Gudgeon Pin—See Pins; Internal Combustion Engine.

The short piece of metal which is fixed inside the piston of explosive engines and serves as a journal for the inner end of the connecting rod is called a gudgeon pin or piston pin.

Guide—A term applied to arms, rods, rails, or similar parts, which serve to keep a moving body in a given path, and to relieve strains.

In steam engines the piston rod cross-head, to which the connecting rod is attached, slides between guides. The long barrel of the cylinder in gas and oil engines serves as a guide to the piston itself, and relieves it from twisting strains. The long boss through which the exhaust valve stem passes acts as a guide to that part. Other mushroom-headed valves have similar guides.

Guide Bars—One of two parallel bars by which the free end of a piston is made to move in a straight line.

Guide-book—A book containing information concerning places, roads, hotels, etc., for the use of tourists; a road-book.

Guide, Cross-head—In a steam engine, parallel bars between which the cross-head moves in a straight line with the cylinder.

Guide Rope—A long rope carried pendent from a balloon to act as ballast to aid in descent, etc.

Gum Lac—A resinous substance deposited upon trees by exudation from the female of a scale-insect as a protection to its eggs and larvæ. When dissolved out, separated from the twigs, and strained through a cloth, it constitutes shell lac, or the shellac of commerce, used extensively in making varnishes, lacquers, etc.

Guncotton—A substance produced by treating cotton or other forms of cellulose with a mixture of nitric and sulphuric acids. It explodes by percussion, particularly when under pressure.

Gunmetal—A metal composed of 90 per cent of copper and 10 per cent of tin, so called because formerly used for making small cannon. The mixture has a tensile strength of 17 tons per square inch. It is fairly hard and very tough. A harder metal is made by reducing the quantity of copper and adding more tin.

This metal is very largely used for the crankshaft and other bearings in motor contruction, and all other bearings, except when balls, rollers, or white metal is used. It should not be confused with yellow brass, which is a mixture of copper and zinc. Bronze is composed of a mixture of copper, tin and zinc.

Gunmetal, How to Braze—See Brazing.

Gunwale—The upper edge of a ship's side; a piece of timber around the top side of a boat.

Gusset—An angular piece of iron inserted in a boiler, tank, etc., where it changes from a cylindrical to a square form, etc., as in the junction of the barrel and firebox of a locomotive, etc. Also an angular piece of iron or kind of bracket fastened in the angles of a motor car frame to give strength and stiffness.

Gusset Plate—A flat plate of metal used to stiffen the junction of two plate members that would otherwise be springy. In the case of frames the gusset plates take the form of triangular pieces riveted on to the corners. In the case of tanks they take the form of triangular webs of tin or brass, soldered or riveted across the corners, for the purpose of strengthening the sides of the tank.

Gutta-percha—A substance resembling caoutchouc or india rubber, but stronger, more soluble and less elastic, obtained as a milky juice which hardens when exposed to the air. It is the sap of a tree native to the Malayan Archipelago. It dissolves readily in oil of turpentine and naphtha, and is used for cements, insulation, etc.

Gyroplane—A form of flying-machine in which a series of revolving aeroplanes driven by a motor operate as the lifting apparatus.

Gyroscope—An apparatus consisting of a rotating disk mounted by very accurately fitted pivots in a ring or rings, also rotating in different ways; used for illustrating various properties of rotation and the composition of rotations. By means of this instrument the rotation of the earth on its axis can be ocularly demonstrated.

Gyroscopic Action of Flywheel—See Flywheel.

Gyrostat—A modification of the gyroscope serving to illustrate the dynamics of rotating rigid bodies. It consists essentially of a flywheel with a massive rim fixed on the middle of an axis which can rotate on fine steel pivots inside a rigid case.

Gyrostatics—The principles which govern the rotation of bodies.

H

H., h.—In electricity, an abbreviation of "henry," the practical unit of electromagnetic induction.

Hack Saw—A small strong frame-saw, with small close teeth, used for sawing metal, as in cutting off bolts, nicking heads of hand-made screws, etc.

Half-elliptic Springs—Same as Grasshopper Springs, which see. Also see Springs.

Half-lap Joint—In couplings, a joint formed by making the ends of shafts semi-cylindrical and placing them together so that the tongue of one fits into the recess of the other; the joint being then covered with a ring or thimble and secured by a key.

Half-speed Shaft—The shaft also known as the two-to-one shaft. See Shafts.

Half-speed Shaft, Function of the—See under Engines; also Cam Shaft, under Shafts.

Hammer—A tool for driving nails, beating metals and the like. It consists usually of a solid metal head fixed crosswise to a handle.

Another meaning of the word relates to "water hammer" in pipes. When the pressure causing a body of water to flow rapidly through a pipe is suddenly withdrawn, the water continues to move forward by its own momentum until checked at a sharp bend, when it is suddenly sent in a backward direction, caused by the rebound, owing to the water being non-elastic. This causes great shock in the pipes, and unless they are strong, and well protected by good curves instead of sharp angles, the water hammer will set up leaks. It has more generally to be guarded against in steam car practice than in the water circulation system of internal combustion engines.

Hammer-break System of Ignition—Same as Make-and-Break System.

Hammering Out Lamp Dents—See Care of a Car on Tour.

Hammering Out Tube Dents—See under Dents.

Hand Brake—A brake operated by hand; an emergency brake. See Brakes.

Hand Drill—A boring tool for metals and other hard substances, operated by hand, in contradistinction from a drilling-machine.

Hand Feed Pump—See under Pumps.

Hand-hole—An opening in a gear-box for purposes of examination and cleaning.

Hand Lever—See under Lever; also Governing and Control and Control of the Gear, under Change Speed Gear.

Hand Pump—See under Pumps.

Hand Pump Lubrication—See Lubrication Systems, under Lubrication.

Hand Wheel—See under Wheel.

Handicap—A restriction or hindrance in a contest imposed upon a competitor of superior skill to offset the supposed inferiority of an opponent; or an allowance of distance, time, or the like given to an inferior contestant.

Handle, Force on the Starting—See under Driving.

Hanger Bolts—In a motor car, bolts that secure the cylinder or motor to the frame.

Hanger, Frame—Same as Dumb Iron and Spring Hanger.

Hanger, Spring—One of the projections from the frame of a motor car from which the springs depend. Also called Dumb Irons.

Hands, Care of the—See Care of the Hands, also remarks under Care and Maintenance.

Hansom—A low-hung carriage or cab for public hire, with two wheels, seating two persons and having an elevated seat or perch behind for the driver. Also, a self-propelled vehicle with similar body and driver's seat, but having four wheels.

Harden—To make hard or more hard in substance or texture, as steel, etc. In the process of tempering steel it is first brought to a proper degree of hardness by heating and suddenly cooling, then it is tempered by reheating to a temperature determined by its color and cooled by immersion in water.

Hardening, Case—See Case Harden.

Hardening, Oil—A process of securing hardness by immersion in oil, sometimes employed in the manufacture of steel.

Hardness—Close union of component parts; compactness; the quality of bodies which resists impression or the separation of their particles. In mineralogy, the quality of bodies which enables them to resist abrasion of their surfaces.

Also the quality imparted to water by reason of holding mineral matter in solution.

Hard Rubber—A vulcanized rubber that closely resembles horn in texture, rigidity, etc. See Ebonite; Vulcanite.

Hard Solder—A solder that requires a red heat to fuse it; used for joining brass, iron, and the more refractory metals.

Hardware—A general name for all wares or objects made of iron or other metal, as tools, etc.

Hard Water—Water containing mineral matter to the amount of ten grains or more to the gallon.

Hatch—A cover for the inspection pit in a garage, etc.; any door or grate covering such an opening.

Hauling a Car—See under Driving.

Head—The upper part or top of an object, as the head of a cylinder or of a nail. That part of a hammer with which an object is struck. The vertical height or available fall of water from a dam, reservoir, etc. In steam and gas engineering, the pressure of steam or gas upon the interior surface of the cylinder or connecting pipes. Thus we speak of a full head of steam.

Head, Combustion—The cylinder head or combustion chamber in an internal combustion engine.

Head, Cylinder—The upper part of a cylinder constituting the combustion chamber in a gas engine.

Headgear for Motorists—See Clothing and Dress.

Heading Tool—A tool with which the rod of metal used in forming the heads of nails, bolts, etc., is held.

Headlight—Generally a powerful acetylene gas or electric lamp placed immediately in front of the car to illuminate the road. See Lamps.

Head Valve—The delivery valve in a condensing steam engine.

Hearth—The floor of a reverberatory furnace on which the ore is heated; also, the lowest part in a blast furnace, through which the melted metal passes into the crucible; also applied to a bloomery, the puddling furnace or forge in which the ore is made directly into wrought iron, taking the form of blooms or short, rough bars.

Hearth, Open—Reverberatory furnaces, having a shallow hearth and using gas as fuel in the manufacture of steel, are called open-hearth furnaces. The "open-hearth process" is the Siemens-Martin process of making steel, melted cast iron being converted into steel by the addition of iron ore or wrought iron and manganese, and by exposure to heat in an open-hearth furnace. The steel made by this process is called open-hearth steel.

Heat—A condition of matter believed to consist in a certain motion or vibration of the ultimate molecules of which bodies are composed; it is a condition or exhibition of energy, of which motion, light, gravity, electricity, etc., are other exhibitions under different conditions. It is the cause of fluidity and evaporation. It expands all bodies, but the expansions are different in different substances. In general, solids expand least by heat; liquids expand more and more rapidly, and air and gases expand most and most rapidly of all. Heat is always manifested through matter and although unequally diffused among bodies it is always tending to an equilibrium. It may be communicated to surrounding bodies either by contact or conduction, or by radiation, the ether being the medium of communication. Its influence at different distances from the place or point whence it emanates is inversely as the squares of those distances.

One British Thermal Unit (B. T. U.) is the amount of heat which will raise 1 lb. water 1° F., namely from a temperature of 60° F. It is equivalent to the work of lifting 772.55 lbs. one foot in height, or to lifting a weight of 1 lb. through a vertical distance of 772.55 ft.

This definition is complete, and the unit is sometimes called "one-pound degree Fahrenheit." It is equal to 251.9 French units of heat called "calories." The calorie, or "therm," is the amount of heat required to raise 1 gram mass of water, from 4° (temperature of maximum density of water) to 5° C.=1 gram-degree Centigrade. It is a much smaller unit than the B. T. U., namely 0.00396 of a British unit. Joule's Equivalent is the amount of energy equivalent to a unit of heat or "therm." It is denoted by J.

Heat, Convection of—See Convection.

Heat Efficiency—See under Efficiency.

Heat Engine—An engine which transforms heat into mechanical work.

Heat Expansion of Nuts—See under Expansion.

Heat, Latent—Heat producing a change in the molecular structure of a body without altering the temperature, as in the conversion of a liquid into a gaseous state.

Heat, Mechanical Equivalent of—In physics the amount of mechanical energy which, when transformed into heat, is equivalent to one heat unit. Joule's experiments, the results of which are generally accepted, gave 772 foot-pounds as the energy equivalent to that expended in raising the temperature of one pound of water one degree Fahrenheit.

Heat Radiator—See Radiator; also Circulation.

Heat, Specific—The number of units of heat required to raise a unit of mass of a substance through one degree of temperature.

Heat, Unit of—The amount of heat required to raise one pound of water through one degree of temperature. Thus one pound of coal, upon combustion, yields about 13,500 heat units, or heat enough to raise 13,500 pounds of water through one degree Fahrenheit. See Heat, Thermal Unit, Calorie.

Heating the Carbureter—See under Carbureter, Driving, etc.

Heating Motor Car House—See Housing under Care and Maintenance.

Heavier Lubricating Oil for Summer—See under Lubrication.

Heavy Oil Motor—In this type of motor a heavy oil is used with a flash point of 84 degrees F., instead of the lighter oil used in gasolene cars. In order to vaporize the oil, it is heated previous to its mixture with air to form the explosive mixture, and this is the only essential difference between the two types of motors. Heavy oil is generally used in steam cars.

In India and other countries where a high temperature exists, this type of motor is very suitable, as light oils are dangerous to use, and expensive and difficult to obtain, except at large centers.

Heavy Traffic Motor Cars—Heavy motor cars for carrying and hauling merchandise in large quantities and of no inconsiderable bulk, are now largely used in the British Isles under this general name. Their great value is found to consist in the much wider distributing area such a vehicle can cover, the greatly increased ton load moved or carried, and the quickened pace of conveying same. The motors are of two classes, steam driven and oil driven, with a preponderance of the former type.

Under existing regulations by the British Local Government Board the term "heavy motor car" means a motor car exceeding two tons weight unladen and not exceeding five tons unladen. Such vehicle is permitted to haul a trailer wagon, but the combined weight (unladen) of the motor vehicle and trailer must not exceed 6½ tons. The maximum of speed permitted is 8 m.p.h., to be reduced to 5 m.p.h. if the weight of the motor vehicle (unladen) exceeds 3 tons, or if a trailer be attached. Heavy motor vehicles fitted with pneumatic tires or tires made of a "soft elastic" material may be driven at the maximum speed of 12 m.p.h., provided also that the axle weight on any axle does not exceed 6 tons; where that limit is exceeded the speed limit is to be reduced to 8 m.p.h. The carrying capacity of heavy motor vehicles and trailers is, according to a scheduled rate by the Local Government Board, at so much per axle. Suitable regulations as regards width of tires, diameter of road wheels, and over-all width of the body are laid down.

Motor vehicles of the sort may be classified thus: (a) Light locomotives of the traction engine type, either self-contained, or (b) in combination with a steel frame and having an extended wheel base. Self-contained vehicles (c) of the ordinary lorry type with the propelling machinery ranged on or under the framing, all these being steam driven machines; or similar pattern vehicles (d) driven by oil motors, chiefly using kerosene fuel.

The features of classes (a) and (b) are identical as regards the mechanical details, the engines—either simple, that is, working on high pressure steam, or compound, that is, working on high pressure steam but utilizing it afterwards expansively in a second cylinder—being mounted on the top of the locomotive type of boiler, and driven either by gear throughout (traction engine fashion) or by part gear and chain to the road wheels.

Self-contained vehicles of the (c) class have their machinery steam driven, mostly on the high pressure system (that is, non-expansively). In the majority the entire propelling mechanism, excluding the boiler, is placed below or about the framing, and is largely incased against dirt, and in one or two instances is arranged to run in a sort of oil bath. The boilers are mostly of the vertical multitubular type, fired from a central or down tube, the flue for the gases being arranged circumferentially in a cylindrical casing or smoke box, terminating in a short smokestack. In its modern form this type of boiler is of much less complicated construction than was used in the earlier types and which proved more or less unsatisfactory in the hands of the unskilled men employed to tend them. In a few instances a locomotive type of boiler is used and is placed fore and aft or transversely. Coke is mostly used for fuel, but oil fuel has been tried with varying success at various times. The working pressure of these boilers varies from 200 to 250 lbs. per square inch. Gear mechanism in conjunction with chains is used to transmit the drive from the engine to the rear road wheels, some of the types being furnished with compensating load or shock absorbing devices.

The vehicles under class (d) use oil motors, some being gasolene driven, others using kerosene as fuel. The gear mechanism is arranged variously, some being driven by a transmission system closely following ordinary gear-driven motor car practice, others by internally geared drivers attached to the road wheels, the power being communicated by meshing spur pinions attached to a differential gear-fitted countershaft, and a third section by part gear and side chains, driving on to sprockets fitted to the hubs of the rear road wheels.

Irrespective of the style of mechanism used, all heavy motor vehicles have a two-speed range of gear fitted, and the oil driven classes have, in addition, a separate train of wheels for reversing. In the steam-driven class, either the ordinary link motion or a "slip" eccentric sheave is used, though in a few types the radial link system is used for the latter purpose.

For various types of American motor vehicles for the transportation of freight see Commercial Cars.

Hecto—A combining form from the Greek "hekton," a hundred, used to signify a hundred, as in hectoliter, a measure of one hundred liters.

Hectowatt—A measure of electrical energy. See Watt.

Height—The altitude, elevation or distance which an object rises above some base or level; elevation above the ground.

"Height over all" is the distance from the ground to the topmost part of an object, as to the top rail of a limousine body or the highest point of a Cape hood, etc.

Helical—Having a spiral form; pertaining to a helix; spiral.

Helical Gear—See Gear or Gearing.

Helical Spring—See Springs.

Helicoid—In geometry, a warped surface resembling that of a screw.

Helicoid Nut—See Bolts and Nuts.

Helix—A spiral line, as of wire in a coil; a winding, or anything that is spiral. In geometry, a non-plane curve the tangents of which bear equal inclinations to a fixed right line—such a curve as is described by every point of a screw that is turned around in a fixed nut.

Helm—The apparatus by which a ship is steered, including the rudder, tiller, wheel, etc., also applied to the wooden or metal bar by which the rudder is shifted.

Hemp Packing—See Packing.

Henry—The practical unit of electromagnetic or magnetic induction, or the induction in a circuit in which the electromotive force is one volt, the inducing current varying at the rate of one ampère per second.

Herring-bone Gear—See under Gear.

Herring-bone Tread—In a pneumatic tire, a tread having a series of V-shaped ridges.

Hexagon Bolt—See Bolts and Nuts.

Hexagon Nut—See Bolts and Nuts. Standard specifications for hexagon head screws, castle and plain nuts are issued by the Association of Licensed Automobile Manufacturers.

High Compression and Efficiency—See under Compression.

High Gear—See Gear or Gearing.

High Pressure—This term generally refers to steam engines and high pressure steam. See Cylinder.

High Pressure Cylinder—See Cylinder.

High Pressure Steam—See Steam Car, under Motor Car.

High Spark; Low Throttle—See under Useful Information.

High Tension—See under Electricity; also Magneto.

High Tension Circuit—This is the circuit comprising the secondary coil of the induction coil, the heavily insulated wire from the insulated terminal on the coil to the plug terminal, and the return through the frame of the motor, though this latter can be ignored. Great care should be taken not to get a shock from the high tension terminals upon either coil or sparking plug, as the full voltage is very high, and when these parts are touched, a partial circuit is formed through the body to the earth, with unpleasant results. Care should always be taken to keep the high tension wires clear of the frame and especially from heated pipes, as the insulation would be partly melted off, and leakage would certainly result.

All high tension circuits should be regarded as containing currents of very great pressure, ready to escape or get away through any weak point that may present itself, and due care should be taken with all wires of such circuits accordingly. See Ignition.

High Tension Circuit, Maintaining—See under Magneto.

High Tension Conductor—Low tension wire may with advantage be protected with braid or tape, but high-tension wire should be without braid or tape near the terminals for fear of the damp retaining quality of any such fibrous protection causing leakage of current.

High Tension Current—The high tension current is a current of high voltage, as distinct from one of low voltage, the terms being comparative only. In motor car electrical matters the term is always used to indicate the induced current in an induction coil, so as to distinguish it from the primary or low tension current. It is sometimes known as the secondary or induced current. See Ignition.

It is the current which in jump-spark systems of ignition is conveyed to the sparking plug at a pressure of about 20,000 volts by a wire very thickly covered with indiarubber.

The high tension current from an ignition coil is not to be considered satisfactory unless it is possible to obtain a spark in air of about ½ an inch in length. This spark should not be weedy and thin, but should appear like a luminous rod about one millimeter thick. It should be capable of setting fire to a piece of thin dry tissue paper after playing upon it for a few seconds.

High Tension Distributers—See under Ignition.

High Tension Ignition—See Ignition; Magneto.

High Tension Ignition, Bosch System—See under Ignition and Magneto.

High Tension Magneto—See under Magneto, also Ignition.

High Tension Magneto, Types of—See under Magneto.

High Tension Wire—A special form of electric wire, made to convey high pressures or voltages. In motor practice the term is applied to the wire which runs from the coil to the sparking plug. The wire itself usually consists of a number of fine copper wires, stranded together, and heavily insulated.

The insulation of the best wires is as follows:—1st coat, nearest wire, partially vulcanized black rubber; 2nd coat, vulcanized white rubber; 3rd coat, layer of tape; 4th coat, partially vulcanized black rubber; 5th coat, layer of tape, or woven hemp; 6th coat, vulcanized black rubber. The order varies somewhat in different makes of wires, but the constituents remain the same. See Electricity; Ignition.

Highway—A road used by the public; a thoroughfare; a main or much traveled road.

Hills, Ascending—See under Driving.

Hill, Attacking a—See under Driving.

Hills, Climbing Dangerous—See Dangerous Hills.

Hills, Descending—See under Driving.

Hints, Miscellaneous—See Care and Maintenance.

Hiring a Car—If a prospective purchaser has practically settled upon the make of car he prefers and wishes to give the make a thorough test it may be well to hire a similar model and run it for awhile. Arrangements may sometimes be made whereby the amount paid for such hire or part of it, can be applied upon the purchase price of a new car.

Hissing Noises—See under Engines.

Hit-and-Miss—A mechanism used in the earliest motor vehicles for the purpose of governing the engine. The inlet valve was opened at each suction stroke by a knife blade, which in oscillating struck the end of the valve stem. The governor was so coupled up that when the speed rose above the pre-determined limit, it altered the position of the knife edge and caused it to miss the end of the valve stem so that no gas was drawn in. See Governor.

Hogging—A bending or drooping at both ends or any similar curvature resembling a hog's back. Said of the keel of a ship or any other structure of like nature.

Holding-down Bolts—Bolts securing one part which rests upon another, such as the engine, gear-box, etc., which are secured to the top side of the frame.

Holding-up Bolts—Bolts which hold one part up to another. In this case the bolts have to carry the weight of the lower part and are, therefore, of larger diameter or increased number as compared with the holding-down bolt.

Honeycomb Radiator or Cooler—In the honeycomb type of radiator or cooler the water is contained in a skeleton structure of exceedingly thin tubes, with intervening air spaces running fore and aft. A small water tank is contained in the surrounding framework of the cooler. These coolers hold only a small quantity of water, but they are so efficient that evaporation is very slight and replenishments are needed correspondingly seldom. The draft set up by the motion of the car is assisted by a fan, driven by the motor. Sometimes the fan is located immediately behind the radiator, where it is generally rotated by a belt. In other cars the motor is boxed in nearly airtight by a shield underneath and a closed bonnet above, and the flywheel (which is behind the motor) has its spokes constructed as vanes, so that the air is drawn right through the "engine room." See Radiator.

Hood—Many forms of hoods for temporary protection on motors cars, either from rain or heat, have been brought out within the last few years. The form most generally adopted is that known as the Cape cart hood, as used for many years on ox-wagons at the Cape of Good Hope. It is attached in many different ways, the frame work generally being of some sort of hard flexible wood, such as ash, and hinged to the body of the car in different places, so that the hood can be let down to lie at the back of the car. A very large variety of adaptations of the Cape cart hood are on the market, for which readers are referred to the catalogues of the manufacturers.

Hood, Cape—See Hood, above.

Hood, Dust—A form of temporary protection for the body of a automobile against dust. See Hood.

Hoods for Lamps—See Lamp Covers, under Lamps.

Hooke's Joint—Another name for a cardan or universal joint.

Hooter—See Horn.

Horizontal—Parallel to the horizon; operated or situated in a level plane.

Horizontal Engine—See Horizontal Motor.

Horizontal Motor—In some well known makes of motor cars the engine is placed in a horizontal position instead of in a vertical position. This necessitates little variation in the motor itself, except that splash lubrication is usually dispensed with, but the casting is made with the supports or lugs in a different position to facilitate securing to the frame of the car. There are a good many vehicles now so fitted.

Horn—The selection and fitting of a horn or hooter for a motor car is really an important matter, for an accident may very easily occur through a horn not being loud enough, or failing to sound when pressed violently on a sudden emergency. It is well worth while purchasing a really good one, having first carefully tested it for volume of sound and certainty of action. It should be secured in a position forward of the dashboard, and with nothing in front of it to check the volume of sound. Sirens, buzzers, exhaust whistles, and gongs are all used for a similar purpose.

Low-toned horns having necessarily a less strong spring to the reed (in order to get the slower vibration rate) are more liable to seal up under a strong air pressure than shrill horns. A shrill horn may be made lower in tone by loading the vibrating end of the reed with a little lump of solder.

Low-toned horns that miss fire may be cured of this defect by slightly bending the reed, but the adjustment requires much patience. This prevents an air seal from occurring, but introduces a leakage of air past the reed, which makes it impossible to sound a long protracted and gentle note. The combination which gives a long note, a low note, and never misses fire is only rendered difficult to get commercially by the cheap price at which horns are sold. The current prices do not allow of proper instrument makers' work being expended on them.

Low notes have the peculiar advantage over high notes of being not only less aggressive, but of traveling round the corner better. This is due to the property of their longer wave length. This is a quality of both light and sound of long wave length, and is the basis of the optical instrument known as a diffraction grating.

The larger the rubber bag the more protracted the note can be made. In order to place the horn well forward it is necessary to employ an armored tube to convey the air to the reed and horn proper. The union between the tube and the horn should be a bayonet socket instead of a screw, so as to allow of the easy disconnection and inspection of the reed without actually removing the horn from its bracket or the tube from its clips for the mere purpose of unscrewing one or the other. The bayonet sockets should be so packed that no air leakage occurs past the joint. For this purpose a spring is generally provided inside it, which forces up the packing pieces into good contact.

In some cars convenient lugs are cast in front of the radiator to carry the horn, so that the driver hears no more of the noise than is necessary to be sure that the instrument is working. The convenient places for the bag of the horn are: first and best, on the top of the steering wheel if there is not more than one engine control lever; secondly, under the steering wheel, clipped to the pillar; thirdly, on the side of the body near the place to which the right hand falls readily after changing speed or applying the brake.

See Accessories; Their Use and Repair, also Tools, Spare Parts and Accessories.

An Awe-Inspiring Horn.

A type of modern horn is seen in the photographic illustration of the "Klaxon" warning signals. These signals, which are made with either long or short projectors as shown in the illustrations can be operated from a regular six-volt storage battery or eight-cell dry battery. On pushing a button the current from the battery starts the self-contained motor at high speed. On the end of the motor shaft is a toothed wheel that strikes a knob fastened to the steel disk or diaphragm. The vibration of the diaphragm produces a sound described as "the most unusual and startling roar that ever greeted human ears."

Horn Bulb—The rubber bulb by the compression of which air is forced into a horn to sound it by operating the reed.

Horn Plate—A flat plate or bracket which is used as a guide to prevent a member taking any but a straight movement—generally in a vertical direction. Horn plates are sometimes used on heavy vehicles to cause the axle to rise and fall vertically relatively to the frame when the springs are deflected; just as they are used for this purpose in locomotive and railroad rolling stock construction. As an instance of horn plates being fitted to a motor vehicle we may refer to a car in which two horn plates are used, with which rollers, attached to one part of the vehicle, come into contact. This prevents the side sway which might be found objectionable in the case of vehicles fitted with full elliptic springs at the rear. The construction has also been found to considerably decrease the tendency to side-slip.

Horn, Spring—One of the projecting supports to which the springs of a motor car are fastened or shackled.

Horseless Carriage—A term formerly often applied to motor cars, but now seldom used as a name for them. In the early days of automobiling when even the names to be applied to the new vehicles were unsettled, the automobile was a "horseless carriage" to all save the manufacturers, owners and drivers of them. In the rapid development of recent years more definite terminology has been adopted with surprising rapidity and though it is but a few years since the phrase "horseless carriage" was heard on every side, it is now to all intents and purposes obsolete.

Horse Power—The unit of power for engines. It represents the power required to raise 33,000 pounds one foot in one minute; or, as usually put, to perform 33,000 foot-pounds of work per minute.

The term is not an accurate measure of the power of a horse, for it has been determined that the average horse, working 8 hours per day, labors at the rate of 0.69 of the theoretical horse power. Or, in other words, mechanical horse power is about one and two-fifths times that of the actual average power of a horse.

French horse power is slightly different from English and American. One American H.P.=1.0139 French H.P.

The horse power of a motor vehicle is rated in a variety of different ways, and some confusion may arise in the mind of the uninitiated as to what any particular horse power really represents. Thus we have the Brake Horse Power, the Indicated Horse Power, the A. L. A. M. rating, and many other ratings determined sometimes by cylinder capacity, sometimes by bore and stroke, sometimes by a combination of these with revolutions per minute. All these latter ratings are purely for purposes of competition and do not represent actual horse power.

Power can only be measured or determined by taking into consideration three factors—pressure, distance, and speed. Without these three factors it is impossible to determine horse power accurately. The unit of horse power was fixed by James Watt in a very simple manner when he introduced the steam engine. It was for purposes of pumping water out of mines, work which had previously been accomplished by horses. It was natural in introducing his engine to mine-owners that he should have some comparison as to what it could do relatively to what was already being done, and therefore the power of the new engine was determined in terms of what a horse could accomplish. Watt decided that one horse power could be represented by the work which a horse could perform in raising water, and this was decided on as the work of lifting 33,000 lbs. one foot high in one minute. It will be seen that here we have pressure, distance, and time; without these three factors no determination of power can be made.

In applying Watt's rating to a motor vehicle it will be seen that all we have to find out is how much pressure is being exerted over a certain distance in a certain time. If distance, or time, or pressure be left out it will be easily seen that the power cannot be determined. A low-powered engine can be made to move as heavy a car as a high-powered engine, but it will not move it so fast. Or it can be made to move a car just as fast, but the car must not offer as great resistance, so that time or pressure—that is, weight or resistance—are of the essence of the calculation.

The power of a motor car can be measured in three ways. In the first way the pressure inside the cylinder can be measured—that is to say, the actual pressure exerted by the expanding gases. If this pressure be measured, the distance through which it is being exerted, and the time during which it is being exerted, it is obvious that the actual horse power of the expanding gas itself can be ascertained. This can be done by means of an indicator, and it is, therefore, called Indicated Horse Power. It really does not represent the true power of the engine, because the friction of the engine itself, and the work which has to be done in the engine itself in lifting its valves, rotating its crank shaft, moving the weight of the fly wheel and the reciprocating parts, such as the pistons, must all be deducted from this Indicated Horse Power.

The power that the engine itself will exert on some outside object, which is the useful power which can be got out of the engine, will be less than the Indicated Horse Power, and so it becomes necessary for practical purposes to measure the power that can be got out of the engine, and this is done at the fly wheel. Here again we can measure how much pressure the engine will exert on something outside it during a certain time and over a certain distance, the three indispensable factors in our calculation. The pressure is measured by absorption; that is to say, the engine is made to work against so much friction that its power becomes absorbed by friction. This enables us to measure the amount of power being given out. (See Dynamometer.) The observation of the power is accomplished by means of a brake put on the flywheel, and so the horse power which is measured here is called the Brake Horse Power.

It is plain that the difference between the Brake Horse Power and the Indicated Horse Power—that is to say, the power which the engine will give out and the power which is generated in it by the expansion of the gas—will be a measure of the engine efficiency as a mechanical appliance. If badly made, of the wrong material, or not properly operated, it will absorb so much in friction in its own mechanism as to make a very appreciable difference between the Indicated and the Brake Horse Power, and the value of the two methods of arriving at the engine power lies in the fact that it is only by comparing them that any idea can be arrived at as to the efficiency of the engine itself. The greater the disparity between the two results the more inefficient is the engine; while the nearer the Brake Horse Power and the Indicated Horse Power approach each other the greater is the engine efficiency.

This brings us then to another point. We talk about a car being a 10 H.P. or a 20 H.P. or a 60 H.P. as the case may be, but this only really deals with the horse power of the engine, and just as a great deal of power can be absorbed in the engine, as indicated by the difference between Indicated Horse Power and Brake Horse Power, so, however efficient the engine is, considerable power may be lost in the mechanism of the car itself. The real efficiency of the car cannot be measured by its engine, and it may happen that some cars with engines of exactly the same Brake Horse Power may show a great disparity in the speed at which they can travel. This will be due, of course, to the absorption of power in the transmission mechanism of the car.

If the horse power given out at the road wheels could be measured we should have three separate and distinctive indications of the efficiency of the mechanism; that is—the measure of the efficiency of the engine as determined by the difference between its indicated and brake horse power; and the measurement of the efficiency of the transmission gear as indicated by the difference between the brake horse power of the engine and the horse power given out at the road wheels. In fact it would seem that, without this latter indication, the efficiency of a motor car would be very difficult to ascertain, and as the transmission mechanism is a vital part of the car and absorbs a great deal of power, it becomes as necessary to ascertain the power wasted in it as in any other part of the construction. This is becoming more and more recognized, and some of the automobile clubs are laying down remarkably ingenious plants for determining this horse power. This can be done by anchoring the car on the top of rotating wheels, the pull of the car being ascertained by means of a spring balance, and the horse power absorbed in the mechanism being plainly indicated according to the speed, the time, and the resistance set up. The different ratings for horse power are as follows:

Indicated Horse Power—The power given out by the expanding gases in the cylinder of an internal combustion engine or by the pressure of steam in the cylinder of a steam engine.

Indicating is accomplished by an instrument known as the engine indicator. This indicator gives a diagram showing the pressure behind the piston at every point of its travel through the cylinder. Given this diagram and knowing the area of the piston, the stroke and the revolutions per minute the I. H. P. can be calculated. The indicator is invaluable to the maker, as from its diagram full particulars as to the best setting of the valves, best time of ignition, and best explosive charges can be deduced. It requires great skill to operate, and is useless except in the hands of a trained engineer. The indicator is difficult to apply to engines of very high speed, such as the internal combustion engines used in motor cars.

Brake Horse Power—The power of the engine which is available for external work. It is usually measured at the flywheel by making this run against a certain known resistance. A brake composed of wooden blocks is arranged around the flywheel and various weights can be applied. The formula for the calculation is:

$$\text{B.H.P.} = \frac{\text{C.R.W.}}{33{,}000}$$

Where C = circumference in feet of brake circle; R = revolutions of flywheel per minute, and W = weight suspended from the brake. See Dynamometer.

Mechanical Efficiency is the ratio between the Indicated H.P. and the Brake H.P., or the proportion of the indicated power of the engine to the amount available for external work.

$$\text{Mechanical Efficiency} = \frac{\text{B.H.P.}}{\text{I.H.P.}}$$

Thus if half the indicated power be absorbed in engine friction, only half is available for useful work, and the mechanical efficiency of such an engine is therefore said to be 0.5, or 50 per cent.

French horse power represents the work required to raise 4,500 kilogrammeters per minute. It equals 32,549 foot pounds. Or, in other terms, 1 American H.P.= 1.0139 French H.P.

Horse Power, Brake—See Horse Power above.

Horse Power, Delivered—See Horse Power above.

Horse Power, Indicated—See Horse Power above.

Horse Power, Loss of—See under Driving.

Horse Power Theory—See Horse Power above.

Horse Power, To Calculate—See under Diagram.

Horses and Cattle, Passing—See under Driving.

Hose—Rubber piping for conveying water. Used in connection with steam cars for pumping up water from roadside tanks or ponds and used in connection with all cars for cleaning. The best hose is always the cheapest; an armored hose, that is hose with a winding of thick spring wire around the outside, is the best of all.

Hose, Air, Uses for—Air hose, of the type commonly used for tire pumps, is capable of a variety of services in an emergency, as proved in the following case: A car was disabled through breakage of the gasolene line from tank to carbureter, long-continued vibration in conjunction with a poor support and poorer soldering having resulted in the shaking out of a stopcock—a break that not only occasioned considerable loss of gasolene before a plug could be inserted, but also left the separated pipe ends two inches apart. A repair was first extemporized with some extra acetylene tubing that happened to be at hand, with the result that the driver soon learned, what he might have known before, that gasolene is a pretty fair solvent of good rubber. It was then suggested that the rubber hose from the pump be used, on the theory that the stout fabric in it would hold it together. This proved to be the case—to the surprising extent of several days' use before a permanent repair was made. By this time the rubber lining. the bore of the hose, was practically washed out, but the closely-woven, heavy canvas next to it was as good as ever, and had prevented more than the slightest trace of gasolene from reaching the outer plies of rubber and fabric in the hose.

Hose Connections—See under Indiarubber.

Hose Coupling—A coupling used for joining hose to pipes.

It is very useful for connecting up the piping of water circulation systems.

Hose Pipe—Piping made of rubber, leather, rubber lined cotton, or other impervious material. Same as Hose.

Hot-tube Ignition—See Ignition.

Housed Gears—Gears that are inclosed for protection against dust and dirt, to decrease noise, etc.

House-lighting Circuit, Charging from—See under Battery.

House, Motor or Car—See under Care and Maintenance.

Housing—The ring of metal formed in a casting to incase either a ball bearing or bush. A sunk well or hole into which another piece is fitted for support. More often used in connection with wood-working and body-making.

Housing a Car—See under Care and Maintenance.

Housing, Axle, Parted—See Miscellaneous Roadside Repairs.

How to Drive—See Driving.

H.P., h.p.—Abbreviation of Horse Power.

H-Quadrant—An ordinary gate quadrant.

Hub—The center of a wheel; the part which revolves around the axle, and from which the spokes radiate.

A flanged hub is used for suspension, or wire wheels, the heads of the wire spokes being held by these flanges. Artillery hubs are distinguished by having long axle boxes, or bearings, as compared with carriage wheels, which have wooden hubs. See Wheels.

Hub, Artillery—A motor car wheel of metal into which the spokes are bolted. See Wheels.

Hub Brake—A brake acting on the hub of the rear wheel. See Brakes.

Hub Cap—A metal cap fitted over a hub to protect the bearing from dust and dirt.

Hub, Steering—See under Steering.

Hunting—This is a term applied to a particular action of an engine governed by a centrifugal governor, which causes it to increase and decrease its speed without proper relation to the load on the governor balls. The action is analogous to that which takes place in a marine engine when the screw propellers momentarily leave the water. The same difficulty appears to be met with in the case of high speed gasolene engines, where the load constantly varies and where the driver is apt to be constantly varying the nature of the gas charge and the time at which it is ignited. When the speed of the engine suddenly rises, owing to the load being taken off—as when the clutch is released in traffic—it immediately races, and the action of the governor not being instantaneous, it takes an appreciable time to act on the throttle or other governing mechanism. The moment it does act, however, it begins to act very rapidly owing to the now abnormal speed of the shaft on which it is fixed. It practically jumps into operation instead of gradually closing the valve or operating the mechanism. The result is that the engine suddenly finds itself cut off from fuel supply, and practically begins to work against its own compression, thus tending to as rapidly stop as the sudden declutchment tended to cause rapid acceleration. The difficulty is added to by the fact that the centrifugal governor balls do not fly outward with a progressive movement relative to the increasing speed.

It would appear that this might be overcome by using a larger and heavier governor with a greater range of movement and running at a rather slower speed. Some patent governors are so arranged by means of link motion that the tendency of the governor to act more slowly at high speeds is counteracted by some lever arrangement, which gives an accelerated motion when the links operating the governor begin to assume a position nearly at right angles to the shaft, at which point, of course, the centrifugal force has least effect in moving the levers outward. As mentioned in the article on Governing this may also be got over to a certain extent, in those cases where the governor controls the amount of lift of the valve, by so shaping the cams that they give approximately the same governing effect as if the governor acted with the same force at all speeds.

This phenomenon of hunting may, in some few cases, be caused by improper adjustment of the levers or links which transmit the motion of the governor to the governing device. Thus, should there be an accumulation of back lash in various links, the sum of this back lash might allow of the governor operating upon this shaft for some little distance before the governing mechanism is affected, and in such a way that, when all the back lash in the various link joints was taken up, the action would come suddenly in the form of a knock, instead of with the steady and regular movement which is necessary in any governor to keep the engine within reasonable limit of speed, above or below that determined as the constant. See Governor.

Hunting of Governor, To Check—See under Driving.

Hydraulic Engine—A motor employing water under pressure as the source of power.

Hydraulics—The branch of science which treats of the motion of liquids, the laws by which they are regulated and the effects which they produce; more particularly, that department of engineering science which deals with the application of the motion of liquids to machinery and of machinery to the motion of liquids.

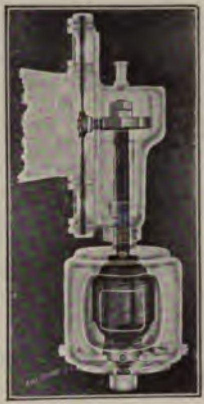
Hydrocarbon Fuels—A general term for fuels consisting of a combination of hydrogen and carbon, like gasolene.

Hydrocarbon Motor—A gas or gasolene engine.

Hydrocarbons—The large and important series of compounds of hydrogen and carbon, forming with their derivatives the subject-matter of organic chemistry.

Hydrochloric Acid—A gaseous compound of hydrogen and chlorine. It is colorless and has a pungent odor and an acid taste. It extinguishes flame and dissolves very readily in water. The aqueous solution of hydrochloric acid has been long known as muriatic acid. See Acid.

Type "S"



X-Ray of Construction.

Horns.—The Klaxon Warning Signal.
Lovell-McConnell Mfg. Co., Newark, N. J.

Type "L"

The Nightingale Whistle.—See Whistle.

Hydrodynamics—That branch of mechanics which treats of fluids, whether in motion or at rest.

Hydrodynamometer—A device to measure the speed of a moving fluid by determining the pressure it exerts.

Hydrogen—An elementary substance existing at ordinary temperatures as a colorless, tasteless and inodorous gas, the lightest of all known substances. It forms one-ninth of the weight of water and is present in almost all organic compounds. A mixture of two volumes of hydrogen and six of air or one of oxygen explodes with violence when brought into contact with an electric spark or with flame.

Hydrolysis—Decomposition of a chemical compound in which the hydrogen and oxygen of water are taken up to form new compounds.

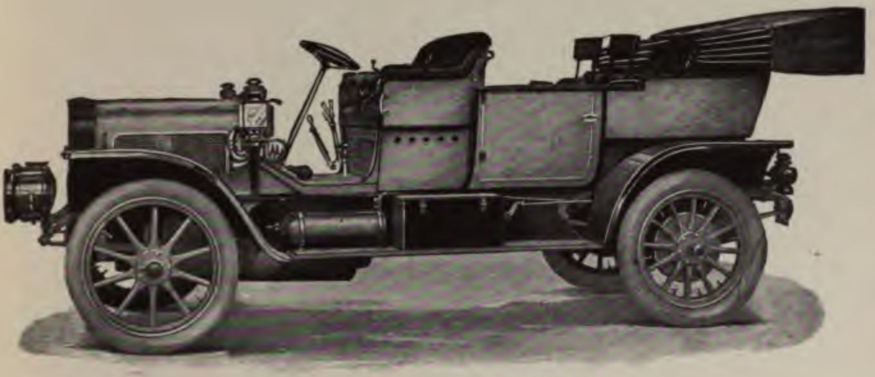
Hydrometer—An instrument similar to a densimeter. In motoring it is generally used to test the specific gravity of the acid in a storage battery, which should show 1,200, or the specific gravity of gasolene. See Densimeter.

Hydrometers are variously constructed. A very common type consists of a graduated stem of uniform diameter and cross-section, a bulb to cause it to float in the fluid and a weight or counterpoise to cause the stem to stand upright as it floats. On being placed in a liquid it sinks until a certain point on the scale is on a level with the surface of the liquid, and from the reading of the scale at that point the specific gravity of the liquid is ascertained directly or by a simple calculation.

Hydrostat—A term applied to any apparatus for preventing the explosion of steam boilers. An electrical device to detect the presence of water and thereby prevent leakage, etc.

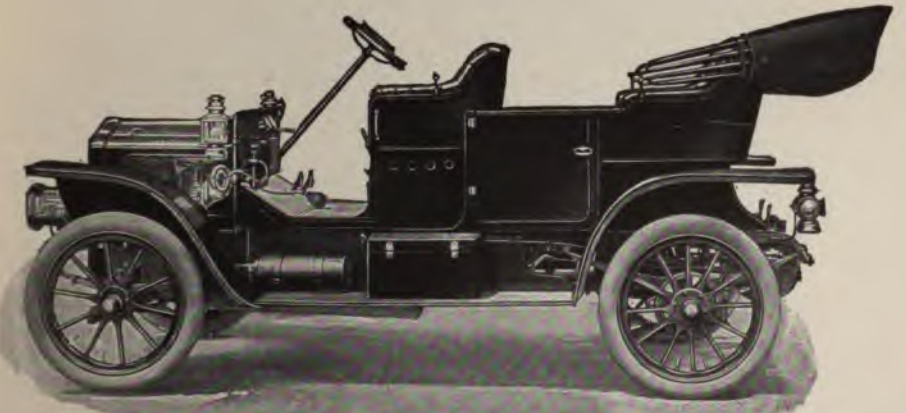
Hydrostatics—That branch of science which treats of the properties of fluids at rest. See Hydrodynamics. It takes into consideration the pressure and equilibrium of nonelastic fluids, the method of determining the specific gravity of substances both solid and liquid, the equilibrium of floating bodies, and the phenomena of capillary attraction.

Hysteresis—In physics, the lagging or retardation of one of two related forces or phenomena on account of some change taking place in the medium through which they act.



Model "M" 40-H.P. White Steam Touring Car.

The Model Furnished to the United States Government for the use of President Taft.



Model "O" White Steamer.

I

Ice in the Carbureter—See under Carbureter, Cold Weather, etc.

Identifying Connections—See under Ignition.

Idle—Ineffective or useless. In mechanics a part of machinery that runs loose, without transmitting power or producing effect is said to run idle.

Idle Coil—A coil in which under certain conditions there is no induced current.

Idle Pulley—A loose pulley which serves only to maintain a strain on a driving belt.

Idler—In machinery, an idle wheel.

Idle Side—The slack side of a driving belt.

Idle Wheel—In machinery, a wheel placed between two others to transfer motion from one axis to another without change of direction. Also, a pulley used otherwise than to communicate motion, as to take the slack of a loose belt.

Ignite—To kindle or set on fire.

Igniter—An insulated metallic contact piece screwed through the walls of the cylinder in the same way as the ordinary sparking plug. It has, however, no sparking points, and is only in metallic connection with a mechanical make-and-break inside the cylinder. Used only in low-tension magneto ignition. See Ignition.

Igniter, Low Tension—See under Ignition.

Ignited Gasolene, Extinguishing—See under Gasolene.

Igniter, Compression—See Ignition.

Ignition—The act of igniting, kindling or setting on fire; also, a means of igniting. A term applied broadly to the apparatus necessary for the ignition of the explosive gases in an internal combustion engine.

Ignition methods may be primarily divided into two systems—electrical ignition and incandescent ignition. So far as the purpose of the motorist goes, the incandescent ignition may be practically left out of consideration. The type of incandescent or catalytic ignition in which a spongy platinum plug is caused to glow or become incandescent under the influence of compressed gas has been experimented with by many, and in the future may provide some measure of success. At present it would appear that the difficulty of accurately timing the explosion is one which has not been overcome, and, until it is, the system may be put out of court as an efficient method for firing a car engine. We are, consequently, left with practically only one broad principle of ignition, that is by electric spark or sparks; but the multitude of means by which this spark can be produced and regulated makes the question very much wider and more complicated than it would at first sight appear.

Before commencing the study of any of the different systems of ignition it will simplify the matter in the mind of the reader to grasp first the requirements of the internal combustion engine in the matter of the ignition. The cycle of operations inside an engine being understood, it will be seen that the first and most important requirement is that the spark for igniting the charge should take place at a predetermined and easily regulated time relatively to the position of the piston in the cylinder. It being one of the requirements of the internal combustion engine, as made to-day, that the gas charge should be compressed in the cylinder, it is obvious that to get the best results it should also be exploded at the time when it is most fully compressed. This time, of course, is the time when the piston has reached the top of its stroke and is commencing to descend. The greater the delay in the generation of the spark after that point has been reached the less will be the power generated by the explosion, not only because the piston has traveled part of its course, but also because for every fraction of an inch it moves downward the compression of the gas charge is being reduced. It is clear then that as well as the electric spark and the method of producing it, we must have some method of regulating the time at which it shall take place.

Putting aside the question as to the production of the electric energy required, it will be seen that we not only require apparatus for its production, but we also require mechanical means for the adjustment of the time at which it should operate. This applies to every type of electrical ignition, and no matter what the source of the electric current may be, there must be this mechanical timing apparatus working in conjunction with the engine and capable of being adjusted.

As to the method of its operation we may take an imaginary case of the simplest form of ignition which it would be possible to use. Consider it as consisting of some source of electric energy, such as a dry battery, some means of conducting the electric current to the inside of the cylinder where the explosion is to take place, and some means of causing it there to give an electric spark hot enough to ignite the gas. If our source of electricity were capable of giving us sufficient voltage and current, we might very easily arrange an electrical system which would consist of a couple of insulated wires leading from the source of supply, and, inside the cylinder, some method of causing the ends of these wires to come in contact and allow the electric current to flow, and then, at the time the ignition should take place, to separate themselves by some mechanical movement operated by the engine itself. It is an electrical phenomenon that when an insulated path conducting a current is suddenly broken a spark will pass between the interrupted ends.

While a system operated on these simple lines really covers the whole ground, yet the actual difficulties to be overcome in applying it to an internal combustion engine, as well as the fact that in its simplest form it would be wasteful, render the adoption of more complicated methods necessary. In the first place, the arrangement of a mechanical contact breaker inside the engine introduces difficulties not easily overcome. In the second place, the nature of the current given out by a dry battery is not the most suitable for this particular work. These difficulties have resulted in the adoption of numerous systems, underlying all of which, however, this fundamental principle will be found. We can divide the systems roughly into two classes, depending on the method of producing the electric energy.

In one case the electric energy is produced by the chemical action taking place between two dissimilar metals or compounds under the influence of an acid or salt; in the other it is obtained from a mechanical appliance provided with permanent magnets, the magnetism of which can be used, under suitable conditions, to produce or induce a flow of electric current; that is to say, the magnetism of the permanent magnets can be turned into electric energy.

The first method uses a dry battery or an accumulator, both being chemical appliances—the first a prime source of electric energy, and the second a storage appliance for electricity produced by any of the known methods and commonly called a storage battery. In the second division the source of power is a magnetic dynamo, usually known as a magneto, and this is driven by the engine. The source of electric energy is thus made part and parcel of the mechanical plant of the car, and independent of any outside source of supply.

The electric system of ignition by magneto is again subdivided into two classes depending on the nature of the current which the machine gives out, about which we shall have something to say further on, but they may be classified here as Low Tension and High Tension. These three sources of current supply—that is, the dry battery or storage battery, the high tension magneto and the low tension magneto—practically cover the entire field, but their application is varied indefinitely, and combinations of any two, or even three, systems are sometimes to be found in one motor.

Battery and Coil Ignition.

We will deal with the system using a dry or a storage battery first. This system is almost invariably of the high tension type, so called because the current of electricity which is used to produce the spark is of high tension, that is to say, it has great power to overcome resistance to its flow, and this is of the utmost importance in any system of electric ignition, since it is the power of the current to jump across the gap which is made inside the cylinder that causes a spark to pass, and it is on the heat of this spark that its efficiency for igniting the gas charge depends.

The source of energy, which may be either dry battery or storage battery, gives off a current which is of the low tension description. That is to say, while there is a good volume of current, it flows with insufficient pressure to overcome any great resistance to its path. It might be described as a great volume of water flowing slowly through a large pipe. Such a flow of water, supposing the pipe were cut, would not induce any very great jet of water. Imagine, however, the same volume of water passing through a smaller pipe in the same time; it would be forced through with augmented pressure, and, if the pipe were cut, the water would squirt out with great force and cover a considerable distance in the air before falling. While this analogy between the flow of water and that of electricity helps us to get the simplest idea of the simplest electrical appliances, yet it is an unsuitable one to carry too far, because there are other ways in which the current of electricity does not act at all like a current or flow of water. For our immediate purpose, however, this difference between the flow of water slowly in a large pipe, and that of a very rapid stream and a fine jet may be taken to represent the difference between the low and high tension electric current. The pressure at which the current is forced through the conductor —a wire—determines its power to overcome the resistance of the gap across which it has to jump in forming the spark.

We have seen that the current given off by a battery or accumulator is of the low tension variety, that is to say, that it has plenty of volume but little pressure. The quantity per second of electricity we measure in terms of amperes; the pressure we measure in terms of volts, and we therefore call a high tension current a current of high voltage—the voltage representing the measure of the pressure of the current, and the amperage representing the measure of the quantity flowing per second. We can convert a current of large amperage and low voltage, such as is obtained from a dry battery or accumulator, into one of high voltage and small amperage, such as is required to produce a spark. This transformation in the nature of the electrical current is brought about by the use of a transformer, commonly known as the induction coil. It is the object of this appliance to alter the nature of the current and transform it from one of low voltage to one of high voltage, such as we require.

The operation of an induction coil or transformer relies on an electrical law which may be stated in a simple way as follows: If a current of electricity is allowed to flow in an insulated conductor, such as an insulated wire in a coil, around a soft iron core, its effect will be to cause the soft iron core to become magnetized, that is to say, it will become a temporary magnet during the whole of the time the current is flowing around the core. To make this plain, we would refer to Fig. 1, in which A B is a bundle of soft iron wires and around it is wound an insulated copper wire—a good many more turns of this being given than are shown in our diagram. C is a dry battery or accumulator from which the current is taken, and from its positive (+) terminal the wire is conveyed round the coil and back to the negative (—) terminal. The result of this arrangement will be that during the time the current flows the soft iron core will become magnetized, having its north pole

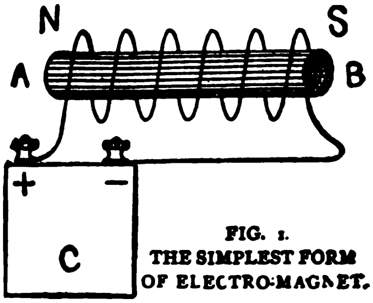


FIG. 1.
THE SIMPLEST FORM OF ELECTRO-MAGNET.

at one end and its south pole at the other. The polarity of the magnet is determined by the direction of the winding, and the north and south poles are marked in our diagram.

Upon this winding of wire conveying the low voltage current, which is called the primary, is arranged another winding of very fine insulated copper wire with a great many turns, called the secondary. If the circuit of the primary or low voltage current is broken, there is induced in the secondary winding a current of very high voltage, and it can be shown that the ratio of the primary and secondary voltages is in the ratio of the turns of wire in each. Thus, if the primary was 100 turns and the battery gives 4 volts, with a secondary winding of 100,000 turns we could, theoretically, obtain 4,000 volts. We do not however, obtain so much as this on account of the resistance of the windings and magnetic leakage, but the elementary theory of a transformer is that the voltages are in the ratio of the number of turns in the windings. On again making the circuit in the primary we again obtain a high voltage current in the secondary, and it is this making and breaking of the current in the primary that causes currents in the secondary. This, then, gives us the high tension current which we require for the purpose of passing across the break in the circuit inside the cylinder and causing a spark.

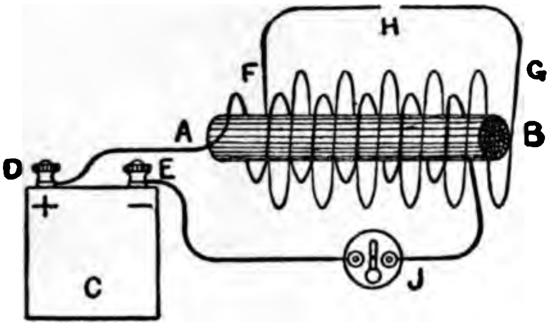


FIG. 2.—SHOWING THE LOW AND HIGH TENSION CIRCUITS OF AN INDUCTION COIL.

In Fig. 2 we show these two windings together, the thick line representing the primary low voltage winding, and the fine line representing the secondary or high voltage winding. The primary winding starts from the positive (+) terminal D of the dry or the storage battery, and flows round through the primary winding of the coil to the negative (—) terminal E of the battery. When started or stopped this induces a secondary current, which flows round the secondary winding of the coil through G and F. G and F do not represent any real part or accessory of the actual coil, but are inserted to show the metallic circuit for the current inside the coil. In actual practice they would represent two terminals on the coil from which insulated wires would run to the sparking plug and some part of the engine or vehicle frame respectively, thus completing the circuit.

Supposing, now, we cut out of this secondary winding at H a small piece, as shown, so that there is a distance of about 0.5 mm. or 1-50 inch, between the ends of the wire, and we put in the primary circuit at J a switch, by means of which we can close the primary circuit or open it, we shall find that every time we open the primary circuit (that is, break the metallic continuity of it by means of the switch so that the current cannot pass), we shall get a spark across the two points at H, due to the fact that the pressure, or voltage, of the current is sufficient to make it jump across at H, and the same again when we close the switch.

It would be understood that the current has a certain amount of what may be termed momentum, so that when an obstacle is opposed to its path, such as the air gap which we make when we break the metallic continuity of the circuit, the momentum of the current will tend to break through the obstacle. It is obvious that the more suddenly the obstacle to the flow of the current is interposed, the more effect the momentum will have in overcoming it. It is the momentum which carries the current across the gap and causes the spark. It can also be shown that, on account of this momentum or what is more properly called self-induction of the circuit, the spark, when the current is interrupted or broken, is greater than when it is made by the switch. This effect of the momentum of the current is also taken advantage of in the condenser, an electrical appliance used in induction coils to increase the sparking effect of the current. Its application and place in the system, a consideration of which at this stage of our investigation would only confuse the reader, is dealt with later.

Supposing this broken part H were on the secondary circuit inside the cylinder, and some arrangement were provided by which the engine would open and close the switch J in the primary circuit, a spark would pass across right in the midst of the gas charge, with the result that the gas in the cylinder would be ignited. This is exactly what is eventually done, but the mechanism required is, for several reasons, somewhat more complicated than that which we have shown.

Let us take first means for breaking the circuit in the primary winding. With an engine working on the four-cycle principle it is necessary to ignite the gas charge once for every two revolutions of the engine, that is to say, every alternate time that the piston reaches the top of the cylinder. The appliance by means of which this is done is known as a contact breaker. Fig. 3 illustrates the simplest form of contact breaker. Here is it shown coupled with the primary winding of an induction coil, shown at C, and with a battery, or accumulator, shown at B. A is a shaft which is driven by suitable gear from the crankshaft of the engine, so that it revolves at half the speed of the engine. It is generally the shaft which operates one or more of the valves. On it is a small projection known as a cam. F is a flexible spring blade, having at its

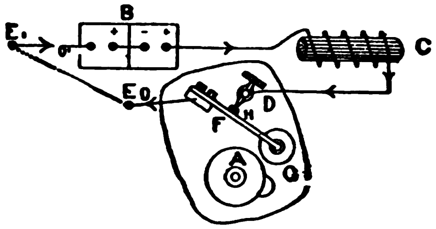


FIG. 3.—THE METHOD OF MECHANICALLY MAKING AND BREAKING THE ELECTRIC CIRCUIT.

end a roller G. The cam on A, as it revolves, comes in contact once every revolution with the roller G, the result being that the spring blade F is lifted. At H it is provided with a platinum contact piece, which, when the cam lifts the blade F high enough, makes contact with the end of the screw D, which has also a platinum point. As soon as the cam has passed the roller G, the spring blade will return to its normal position, and contact between F and D will be again suddenly broken.

Now D is connected by an insulated wire to one end of the primary winding of the coil C, the other end of which is connected to the positive (+) terminal of the battery B. D is insulated from metallic contact with any part of the engine by means of a suitable insulation, but the spring blade F is fixed by metallic screws to a plate which is in metallic contact with the engine. The negative (—) terminal O1 (Fig. 3) of the battery is also connected by an insulated wire with some part of the framework of the engine or car, it being one of the laws governing the behavior of electric current that it will flow back through what is termed "earth" or "ground" to the source of supply. It is, therefore, unnecessary to lead the current back by an insulated conductor so long as whatever it is coupled to has metallic connection right through to the other terminal of the battery or accumulator.

Suppose, then, we imagine the current starting out from the positive (+) terminal of the battery B, traversing the coil C, passing through the screw D to the contact piece at H (while they are in contact with each other), and so through the engine and frame of the car back, by means of the terminal E (which is connected to the frame somewhere), to the negative (—) terminal of the battery. It will be seen that this current can only flow when the cam A has lifted the blade F into contact with the screw D, there then being a complete metallic circuit for the current. The moment the blade F is released, when the cam has passed the roller, the circuit is broken and the current ceases to flow. It is only during the time that the current is flowing that the soft iron core C becomes a magnet, its magnetism ceasing almost instantaneously as soon as the contact is broken at H. In actual practice this contact breaker is arranged so that, within certain narrow limits, the time at which the cam on A will leave the roller G can be adjusted. This is done by allowing the whole of the mechanism, including the blade F, the contact screw D, and the roller G, to be oscillated round the shaft A. This completes the low tension circuit.

In Fig. 4 both circuits, the primary or low tension and the secondary or high tension, are shown. If the diagram is examined it will be seen that the low tension wire is exactly the same as in Fig. 3, but is here shown with double lines.

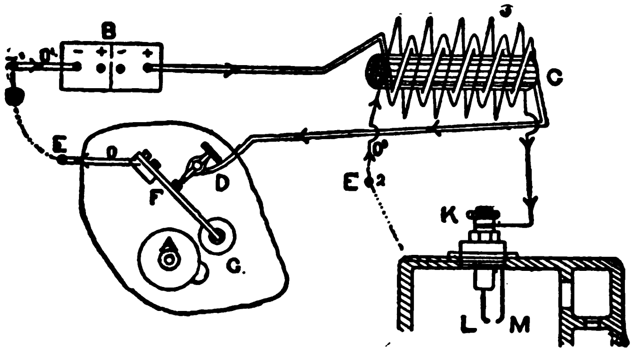


FIG. 4.—DIAGRAM OF A COMPLETE ELECTRICAL IGNITION SYSTEM.

The secondary winding will be seen indicated by fine single lines surrounding the low tension winding on the core C. E is some point at which the insulated wire, forming the secondary circuit, is metallically attached to the frame, or, as it is technically termed, "grounded." As soon as the contact maker makes contact the current flows round the primary circuit, as before described, and when contact is broken induces in the secondary circuit a high tension current. This flows from the coil C to an insulated plug in the cylinder.

This plug is formed with a central porcelain barrel or cylinder, down the inside of which runs a wire L, the end of this being of course, inside the cylinder. Another wire M, terminating in a point, is metallically attached to the body of the plug, which, being screwed into the cylinder head, is in metallic connection with it. The high tension current will thus flow down the insulated wire L, and to get back to the coil again through the engine and frame of the car it must jump across between L and M. It thus causes a spark across between these two points the moment contact is broken by the contact breaker at F, the result being the explosion of the charge inside the cylinder. The plug shown at K is known as the spark plug, and in all systems of ignition, except the low tension magneto system, a spark plug of this description becomes necessary.

This air gap between M and L is an important feature of the appliance. Air is a non-conductor—that is to say, a current of electricity cannot pass through air unless it has a high tension or voltage, nor can it pass through any very great body of air. Moreover, if the air be compressed, the difficulty of getting the current to pass through it is considerably increased. It is necessary, then, to so arrange the points M and L that the distance between them is not so wide as to cause too great a resistance to the passage of the high tension current through the air between them; the closer they are together, the easier it is for the current to jump across. On the other hand, if they are placed too close together, the current will pass so easily across that only a modified spark will take place, and it may be that this spark will not be of sufficient heat to ignite the gas charge. In usual practice, with the voltage of current generally used for motor engine ignition, the distance between these two points may be fixed at about 0.5 millimeter, or 1-50 inch. When magneto ignition is used, as will be described later, it has been found that the distance of the points of the sparking plug from each other requires to be less to give the best results, and one of the best known firms of manufacturers of these appliances recommends a distance of 0.4 millimeter. The resistance set up by compressed air to the passage of the current has to be remembered in adjusting sparking plugs, because a spark which would be sufficient to ignite the charge at atmospheric pressure might be found so attenuated when taking place inside the cylinder, with the high pressure often reached there, as to be incapable of firing the gas charge.

The system of ignition which we have just described is applicable to any internal combustion engine either of one or more cylinders, or of the two or four cycle type. In the case of the two cycle type, the make-and-break will take place at every revolution of the engine shaft, because in this type of engine there is an explosion on every down stroke of the piston. Where engines with multiple cylinders are concerned, the method of arranging the ignition varies considerably, and we may subdivide these methods as follows:

(1) Where there is a separate induction coil to each cylinder.

(2) Where there is a single coil for all cylinders.

In the first method it will be necessary to have a contact breaker or maker which will act as a distributer—that is to say, it will have to be so arranged that the low tension current from the battery or accumulator is sent alternately to each of the coils.

In the second method, one contact maker will send the current to the single coil every time a cylinder is to be fired. In the case of a four-cylinder engine this would mean twice for every revolution, and the high tension current in the single coil would be generated each time a cylinder was to be fired. In this case it becomes necessary to have some arrangement to distribute the high tension current to the cylinders in rotation, and this means that in addition to the contact breaker driven by the engine, there will have to be a mechanical appliance, also driven by the engine, to distribute the high tension current. The arrangement of the wiring for these two different methods will be dealt with later, but we may say that the latter method of dealing with the high tension current is known as synchronizing the ignition, because, there being one coil, the interval of time between the flow of the low tension current and the induction of the high tension current will, in all cases, be the same for all cylinders; whereas when a separate coil is used for each cylinder, variation in the conductivity and the inductivity of the coils may arise, and cause differences in the timing of the different cylinders, which would affect the running of the engine to a considerable extent.

There is another appliance used which as yet we have not mentioned. This is the trembler. The trembler is, in most cases, part of the coil, and one of its functions is to make and break the circuit in the primary winding of the coil rapidly and frequently. In the diagrams which have been drawn there would obviously be only one break of the low tension circuit, and correspondingly there would be only one wave of current in the high tension circuit. There would also be disadvantages, which have been overcome by using the trembler as the appliance whose function it is to break contact—leaving the mechanically driven appliance on the engine to make contact.

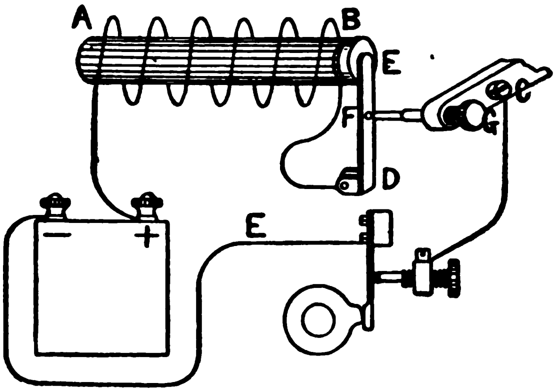


FIG. 5.—THE TREMBLER ON THE COIL

The object of the trembler is, by electrical means, to make and break the circuit rapidly so as to insure more than one spark across the sparking plug, because at every break a spark will pass in the high tension circuit.

In Fig. 5 is shown the action of the trembler, and in this diagram only the low tension winding is included, it being understood that the high tension winding is around this, and that the high tension circuit will be broken just the same as the low tension, owing to the inductive effect ceasing when the break takes place in the primary circuit by means of the trembler. AB is the soft iron core, and opposite to it is arranged a spring blade F, firmly fixed to the coil case at D. At its outward or free end it is provided with a circular soft iron armature E, which normally lies just opposite the end of the soft iron core AB, but a very small distance from it. On the blade F is a circular platinum point, which comes opposite a platinum point at the end of a screw G. This screw G is in circuit with the low tension winding, and as soon as the engine makes contact at the contact maker (as it is called in this case), the current flows from the battery positive (+) terminal around the coil to the plate at D, through the plate and across the contact point F, through the screw G, through the contact maker on the engine, and to ground, which is indicated by the line marked E.

Immediately this takes place, however, the soft iron core AB becomes magnetized and draws the soft iron armature E towards it, the spring blade F allowing of this. It will be seen, however, that the moment this blade is deflected toward the core, the contact will be broken across the point F and the screw G; the current will then, of course, cease to flow through the coil, the core will immediately become demagnetized and the spring blade F will resume its normal position, being no longer attracted by the core. In doing this it will again make contact, the current will again flow, the core will be again magnetized, the armature E will be again drawn toward it, and contact will be again broken. This cycle of operations will continue at a very rapid speed, the speed depending to a large extent upon the nature of the spring F. This is exactly the same arrangement as in an electric belt, where the hammer is connected to a spring so attracted to and released by an electro magnet.

As a result of the action of the trembler, there will be a very rapid making and breaking of the low tension current, and therefore a very rapid series of currents induced in the high tension circuit, so that at the sparking plug there will be a series of sparks. Opinion is not unanimous as to the real utility of the trembler, but it is almost universally used.

It is a great advantage that the break takes place very rapidly, for the more rapid the break the greater the power of the current to jump the gap. In the case where no trembler is used on the coil, but where the engine breaks contact, as in Figs. 3 and 4, the speed at which contact is broken is determined by the speed of the engine, because the rapidity with which the cam on the shaft A leaves the roller G determines the sharpness with which the contact points at F will separate from each other. It will be seen, therefore, that with the method where a trembler is used we can do away with the necessity of a quick break of the contact, and the mechanism on the engine has for its function the making of contact, rather than that of breaking it, the latter function being left to the trembler on the coil. The engine appliance, therefore, becomes a contact "maker," and can be arranged in a different manner from the contact breaker, it only being necessary to provide for the closing of the circuit, the speed at which it is closed being, within certain limits, immaterial.

Where more than one coil is used, one trembler can be utilized for all the coils, it being put into circuit with the low tension winding, and having a separate electromagnet or coil of its own to operate it as a trembler. In this way a trembler need not necessarily be part of the coil; it may be inserted anywhere in the primary circuit. When such a trembler is used separately, it of course must have a coil and soft iron core of its own, the convenience of having it in the coil being that the magnetism of the core of the coil and the primary winding may be used to operate the trembler, thus doing away with a multiplication of parts.

We have now dealt in diagrammatic form with the principles which underlie the different arrangement of the appliances for a high tension ignition system. It will, therefore, be advisable to describe the different ways in which the various appliances may be coupled together for different types of engines. The wiring up of such an ignition system often seems to be complicated, but if we start from a simple system, and describe the principle on which the electrical circuits must be arranged in all cases, no difficulty will be experienced in following even the most intricate arrangement. In the first place, it must be borne in mind that no current can pass from any source of electrical energy unless it has some metallic conductor—that is to say, from the positive (+) terminal of the battery or accumulator or any other source of electrical energy there must be a metallic connection right through to the negative (—) terminal. Whenever this metallic connection is broken or interrupted, no current can flow. This, of course, is true practically of any current of electricity, with this great exception, that if the current is of sufficient voltage it may be made to jump across an air gap.

This conductor or metallic path for the current must be insulated from other metallic parts in order to lead the current, as it were, to the place where we want it to do work. Having led the current by these insulated paths through all the appliances necessary for the working of the ignition, it is not necessary that we should provide an insulated path for it to get back to the battery or accumulator. As a matter of fact, it is, strictly speaking, incorrect to say that the current flows in either direction; but for purposes of making it clearer, and for this purpose only, we may consider it as flowing from the positive (+) terminal of the battery to the negative (—), although it is really immaterial in which order we couple the battery up to the different mechanisms which are incorporated in the system. We can regard it that the current, having been led to the place where the work is to be performed, will find its way back through the mechanism of the car or engine if we lead it to the latter by an insulated wire. This we call "grounding" the current, and the points at which we attach the insulated wire to the car are termed "grounds." It is obvious that to lead the current back in this way the battery must also be connected to some metallic part of the frame.

Another point to remember is that it is not very material in what relative order in the circuit the different appliances shall be coupled or inserted. Thus we might lead a wire from the battery straight to the contact maker on the engine, through that to the coil, and from the coil to ground; or we might lead the wire direct from the battery to the coil, out through the coil to the contact breaker, and from the contact breaker to ground; the place at which the contact is broken in the circuit, whether it comes before or after the coil, being quite immaterial. Convenience in the design of the mechanism itself generally results in the contact breaker being the last mechanism in the circuit, because then only one part of it need be insulated, the current flowing through the mechanism itself and the engine, back to the battery or accumulator. It will be seen that this is purely a question of convenience, and is not an arbitrary arrangement of the different connections.

This necessity for a metallic circuit for the flowing of the current applies both to the low tension and the high tension circuits, and the grounding of the current applies to both. It must be understood, too, that both for the low tension and the high tension currents there must be complete metallic circuits, separate and distinct from each other. It greatly simplifies the comprehension of the system if we remember that these two are separate and distinct currents, that it is not the low tension current in another form which is sent out by the coil, but that the coil may be considered as actually being the source of the high tension current. This necessity for a complete circuit for either high or low tension current applies to every form of ignition, whatever the source of the electrical energy; thus it applies to both the high and low tension magneto systems, which we shall describe later.

We may now take a simple form of wiring where there is one cylinder. It may be well here, for the convenience of motorists who may use these descriptions to help them in wiring up their electric ignition systems, to point out that on different coils different internal windings are arranged, and sometimes one terminal can be used for two purposes, the coupling up inside the coil being arranged to allow for this. The figures or letters on the different terminals of the coils designating their purpose also vary, according to whether the coil is of American, British, French or other manufacture, and also with different makers. The coil, of course, has to carry both the high and low tension circuits through it; therefore there must be provided terminals for these two circuits. The following letters and their meanings in English and French will enable most users to wire up the ignition system correctly. The terminal which connects the coil to the battery may be marked P, B or A. P represents in French "pile," or battery, and is used by French makers indiscriminately to refer either to an accumulator or any kind of primary battery. B on an American or British coil will mean battery, and A will mean accumulator, but it must not be confounded with B on a French coil, which usually stands for "bougie," the French name for the sparking plug. The terminal on the coil for the connection with the contact breaker or contact maker will be marked on a French coil with T, standing for "trembleur," the French term used for a contact maker or a contact breaker. On an American or British coil this will often be marked C. The wire which conveys the current to ground will be attached to the terminal marked on a French coil M, which stands for "masse" (frame), the equivalent of our electrical term "ground." The terminal carrying high tension current to the sparking plug, as we have seen, will be marked B for "bougie" on a French coil, while on an American or English coil it will sometimes be marked S, sometimes P, and sometimes SP.

It will be seen that the two letters P and B, according to whether they are used on American or other coils, stand for different appliances; thus: B on an American coil is battery, and B on a French coil is "bougie," or sparking plug. P on an American or English coil may mean plug, while on a French coil it will mean "pile" or battery. The fact that no American coil will be marked with the letter M at any of its terminals, and that practically no French coil will be without this letter on some terminal affords some guide as to whether the coil is of American, English or French manufacture, and will enable the user to determine what the different terminals are for.

Let us now take the wiring of a simple electric circuit, such as that used on the single-cylinder De Dion car (Fig. 6). This is a system in which the contact maker acts as the trembler in the same way that we have explained in the earlier part of our description of the ignition methods. Here we have the battery, or accumulator, and from the positive terminal of this a wire runs to the terminal P on the coil. This terminal P conducts the current through the primary winding of the coil, after which it leaves the coil at the terminal A, and from there is led to the contact breaker on the engine. From the contact breaker it passes across the contact breaker points to earth (ground) in the engine and so back to the battery, the negative (—) terminal of which is connected to earth. In our diagram the insulated wire connecting the negative (—) terminal of the battery to earth, or the frame of the motor, is intercepted by a switch or plug.

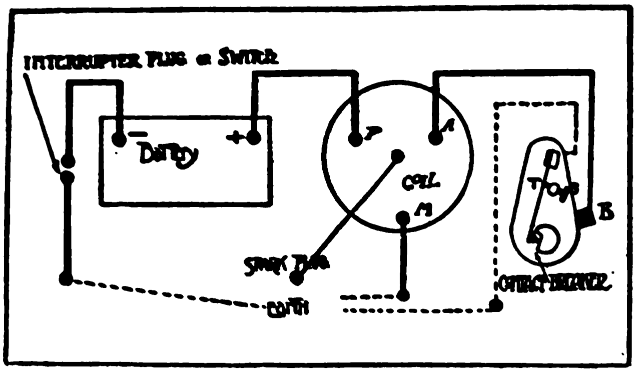


FIG. 6.—THE CIRCUIT OF A SINGLE-CYLINDER ENGINE.

This is very convenient for putting the ignition system out of action, so that under no circumstances can the current flow, even if the engine is rotated to make contact at the contact breaker or maker. It is well to say here that this switch or interrupter can be put in any part of the circuit of the primary current, and at whatever part it is put in it will completely prevent the current flowing through the circuit. In this diagram the secondary winding of the coil is represented by the central terminal, from which a wire runs to the sparking plug. This secondary circuit is grounded through the terminal M, from which a wire is led to any part of the engine or chassis frame. The other end of the high tension circuit is grounded through the sparking plug by means of that part of the sparking plug which is screwed into the cylinder. This is the simplest form of wiring for any kind of electrical ignition on the high tension system and using a dry battery or accumulator and a coil.

In the case where two cylinders have to be fired and where two coils are used, the contact maker or breaker must act as a distributer and distribute the low tension current alternately to one or other of the two coils. In Fig. 7 we have the battery, from the positive (+) terminal of which the current is conducted to the low tension wiring of the coil on the left-hand side. Having traversed the low tension winding of the coil, the current is taken from terminal marked 2 to one of the contact screws of the double contact maker or breaker. When this makes contact with the platinum contact screw, which is marked S, the current flows through the contact breaker to

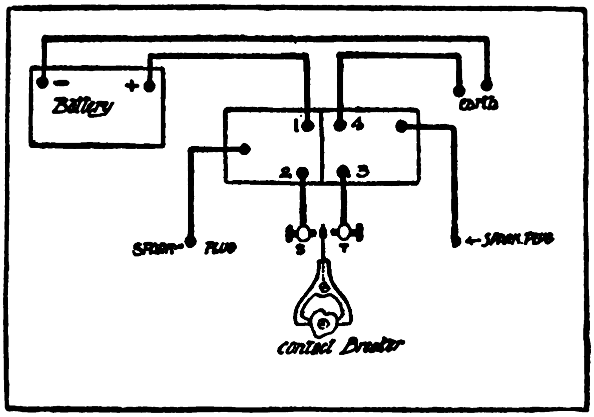


FIG. 7—A SIMPLE IGNITION CIRCUIT FOR TWO CYLINDERS

earth through the engine and back through the negative (—) terminal of the battery, which is grounded as shown. The high tension current is then induced in the secondary winding of the coil and flows out of the terminal of the coil to the spark plug. Exactly the same thing takes place when the contact maker or breaker makes contact with the screw T on the right-hand coil. This causes the current from the battery to flow through the primary or low tension winding to the right-hand coil, and out at the terminal 3 through the contact breaker and grounded terminal to the battery. It induces a high tension current in the outer winding of the coil, and this flows through to the sparking plug in the second cylinder, and from that is grounded through the engine. The high tension current induced in both coils is grounded through one terminal common to both, and marked 4. By this arrangement the contact breaker alternately makes and breaks the circuit of the low tension current in either coil, and it is at the time of breaking contact that the spark passes across the points of the sparking plug.

If instead of using the De Dion contact breaker the cam which operates it were so arranged as to make contact for some appreciable length of time, and each coil were provided on its low tension circuit with a trembler, this diagram would represent the arrangement adopted where two trembler coils and one contact maker are used, as is the case in the majority of two-cylinder cars. The features in which the De Dion system differs from others are as follows: It uses a contact breaker instead of a contact maker, and this appliance, driven by the engine, takes the place of the trembler used in other systems, where the engine-operated appliance is used, not to break contact, but to make contact, as we have described earlier.

Supposing now that we wish to use a single coil with a two-cylinder engine, we should have to arrange it as shown in Fig. 8. In this case the wire conveying the low tension current runs from the battery direct to the primary winding of the coil at A. Having left the primary winding of the coil at the terminal B it flows to the contact maker, and this is arranged so that the wiper C will make contact at two places, D and E, at each revolution; that is to say, it will ground the low tension circuit once in every revolution of the engine. Hence it is apparent that a high tension current will be induced in the coil once in every revolution of the engine and the coil, having a trembler, as described, on the low tension circuit, the secondary or high tension current will be violently and rapidly broken once in every revolution. It is necessary to provide some means of distributing this high tension current alternately to one or the other of the cylinders. This is done by means of a high tension distributer. The high tension distributer is very much like the low tension wipe contact maker, but has to be differently designed so that it will carry the higher voltage of current. The central wiper of this will be insulated, the high tension current being conveyed to it from the terminal F by an insulated wire and some form of spring insulated contact, generally a carbon brush. The wiper is shown at G. It travels round at half the speed of the en-

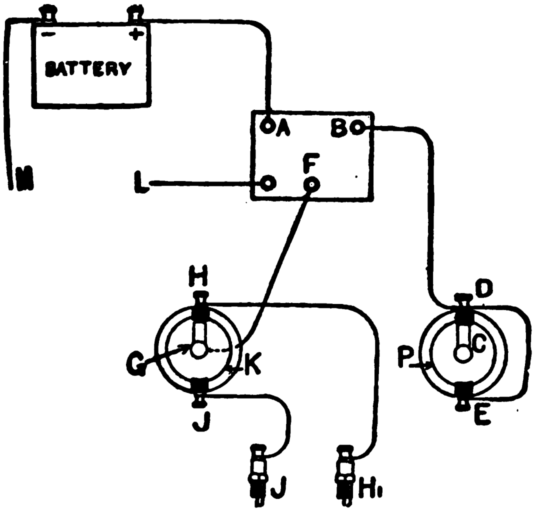


FIG. 8.—SHOWING WIRING FOR TWO-CYLINDER ENGINE WITH ONE COIL AND A DISTRIBUTER.

gine shaft, and as it does so comes opposite, every half revolution, to two insulated segments in an insulated ring, the segments being marked in our diagram H and J, and the insulated ring K. Segment H is metallically connected to one of the sparking plugs in one cylinder, while J is connected to the other, the sparking plugs being represented by H1 and J1. The high tension current is grounded from the coil at L.

If we follow this wiring out we shall see that the current flows from the positive terminal of the battery to the terminal A on the coil, through the primary winding of the coil to B, and from B to the two contact pieces on the contact maker P; so that, every time the wiper C of this contact maker makes contact with the two contact pieces D and E, the current will flow through the primary winding of the coil to ground, the wiper of the contact maker being in metallic connection with the engine. Every time this low tension current flows through the primary circuit the high tension current will be induced in the secondary winding of the coil. That is to say, the high tension current will be induced once in each revolution of the engine, because the contact maker only revolves once in every two revolutions of the engine and makes contact twice in each of its own revolutions.

The high tension current flows through the coil to the wiper of the high tension distributer G, and this also revolves at half the speed of the engine, so that every time the low tension contact maker makes contact the high tension distributer is also making contact with one or other of the two segments H and J; and so when it makes contact with J it will conduct the high tension current to the sparking plug J1 in one cylinder, while, when it makes contact with H, it will conduct or distribute the current to the sparking plug H1 in the other cylinder. The high tension winding of the coil being earthed at L, the current, whether it is sent to one or the other of the two cylinders, will flow back through the metal of the cylinder and car to the place where the high tension current is grounded at L.

This diagram does not illustrate a mechanism which is used in all cars. The contact maker may be arranged quite differently, also the distributer, as far as its mechanical features go; but the principle is the same in all, and this principle governs the use of a single coil and trembler for any number of cylinders.

From this illustration it will be understood that wherever one coil only is used the low tension circuit must be made and broken every time a cylinder has to be fired, and the high tension current must be distributed by some form of distributer in rotation to the different cylinders. It may be said that in the case of a two-cylindered engine it rarely happens that the high tension distributer is used, as it involves the extra mechanical movement driven by the engine, which would be more expensive to manufacture than would be the fitting of one extra coil; but where four or more cylinders are used the synchronization obtained compensates for the extra mechanism, the expense of which is hardly increased by the number of cylinders which it is arranged to distribute to.

Coming back again to the system where a coil is used for each cylinder, and where four cylinders are to be fired, we will describe a case in which two accumulators (storage batteries) are used, either of which may be put in operation at the will of the driver. This will enable us to see how this arrangement may be carried out not only in a four-cylinder engine, but in an engine of any number of cylinders. In Fig. 9 is shown the wiring of a four-cylinder engine where there is a separate induction coil to each cylinder, and where the low tension cur-

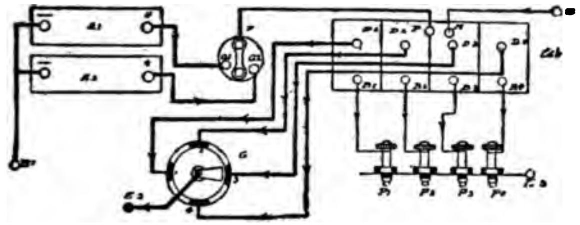


FIG. 9.—THE WIRING OF A FOUR-CYLINDER ENGINE WITH FOUR COILS.

rent may be provided from one or the other of two accumulators. The accumulators shown at the left-hand of the diagram are marked A1 and A2. Both of their negative (—) terminals are grounded at E1. The current flows from the two positive (+) terminals to two terminals A1 and A2 on a switch. The switch is capable of connecting either of these to the terminal F on the switch. From F the insulated wire leads the current to the terminal P on the coil.

By the manipulation of the switch either accumulator A1 or A2 can be made to discharge the current to the terminal P on the coil. Inside the coil box the terminal P connects up to the primary winding of each coil, and from the primary winding of each coil the current flows by means of the terminals D1, D2, D3, D4, to the contact maker which is shown at G. On this contact maker are four segments marked 1, 2, 3, 4; these are completely insulated from the engine, and a central wiper, which rotates at half the speed of the engine, is arranged to come in contact with these four segments in turn. In the position shown, the central wiper is in contact with segment No. 3; and, therefore, with coil No. B3. Presuming the switch is connected to one or other of the accumulators, the current will flow through the switch at F, through the primary winding of the coil B3, out at terminal D3, through the segment and the rotating wiper, and to ground in the metal of the engine, forming a complete circuit. During the time that it is flowing it will be inducing a high tension current in coil B3, and this high tension current will flow from the terminal in coil B3, through the sparking plug P3, and so to ground in the engine. The other end of the high tension winding of coil B3 is connected to the terminal M, and flows to ground at E. This terminal M is common to the end of the secondary winding of all four coils.

During the time that coil B3 is in operation, it will be seen that no low tension current can flow through any of the other coils; but as soon as the wipe contact maker makes contact with any of the other three segments, it will cause the low tension current to flow through the corresponding coil, induce the high tension current in that coil, and cause a spark at the sparking plug which is connected to that coil.

In the case of each coil there is a separate trembler, and it is necessary in this system that the tremblers should be so adjusted as to give the same rapid make-and-break as each other; otherwise synchronization cannot be insured. It is for the reason that it is rather difficult to adjust four different tremblers on four different coils to give sparks of the same value, so far as igniting the charge goes, that synchronized ignition with one coil has become popular with many manufacturers and, as we said before, while necessitating the use of another mechanical movement on the engine, it does away with the multiplication of coils, with the necessity of adjusting tremblers to synchronize with each other, and of various troubles connected with induction coils.

The two-way switch allows of either of the accumulators being put into action—one generally being used as a stand-by. With such a system, in case of the accumulators being partially run down, and firing being precarious, it would be possible, by connecting the terminals of the switch A1 and A2 and the switch lever F together by any suitable means—such as the interposition of a strip of metal—to use the two accumulators in parallel, in which case their amperage would be increased, but this would not, of course, increase their voltage. It is not an advisable thing to do, but in an emergency it might be the means of getting the car home. Sometimes, also, by coupling the batteries in series one may be able to get a car to run with nearly exhausted batteries.

Reverting again to synchronized ignition of a number of cylinders, we may refer to the case of a six-cylinder car using one coil and one accumulator; this is the method adopted in the Napier (Fig. 10), and in this, as in the example shown in diagram 8, there is only one low tension circuit.

The current flows from the positive (+) terminal of the battery A to the terminal P on the coil; it then flows through the primary winding of the coil and the terminal D, and is taken to a wiper on a wipe contact maker F. The rotating part of this mechanism is geared so as to run at half the speed of the engine, a helical wheel on the shaft K driving it. It will be seen that it has six projections on its edge, so that the wiper comes in contact with it six times. It is connected to ground by a spring plate H, which insures a permanent contact between the rotating part and the metal of the engine. Every time that one of the six projecting parts of this contact maker comes in contact with the wiper blade the current flows from the battery through the low tension winding of the coil, and through the contact maker to ground, returning to the negative (—) terminal of the accumulator, which is also grounded.

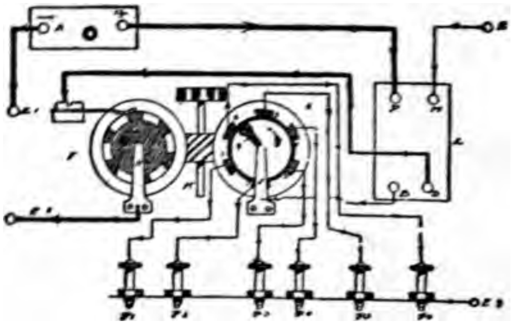


FIG. 10.—THE SYNCHRONIZED IGNITION SYSTEM OF THE SIX-CYLINDER NAPIER ENGINE.

Similarly each time this current flows through the primary winding of the coil the high tension current is induced in it, and thus flows from the terminal B to a central plate J, which is in contact with a rotating wiper R inside the high tension distributer.

On the outside ring of this are six insulated segments marked 1, 2, 3, 4, 5, 6, and as this central wiper rotates it comes opposite to each of these segments in turn. It is so geared that it comes opposite to one at the same time that the wiper on the contact maker F makes contact with one of the projecting pieces. Each of these segments in the distributer is connected to its own plug, and as the high tension current is induced at each one-sixth of a revolution of the distributer it flows to the plugs, the trembler on the coil causing the spark inside the cylinder, into which is screwed the particular plug which is brought into circuit.

In the case of a high tension distributer it is not necessary that there should be absolute contact between the wiper and the segment; in fact, it is desirable that there should not be. Where contact is actually made, metallic dust, caused by the abrasion of the surfaces, sometimes gets incorporated in the insulating material, and causes metallic contact to be made before the wiper reaches the segment, owing to the high voltage of the current being distributed. In cases where contact is not made, the high tension current jumps across the very small space left between the wiper and the segments.

The Napier system of ignition has been slightly altered since the drawing of these diagrams, but in no way which affects the principle upon which it is based. For the newest arrangement of the Napier synchronized ignition, see Timing.

With slight variations, the systems which we have described cover the range as far as high tension ignition by coil and accumulator is concerned.

The mechanical arrangements of the contact makers and the contact breakers, and also of the high tension distributers, vary with different makers; but the principles involved are always the same, and an intelligent grasp of the examples given will enable a motorist to understand any ordinary system of high tension ignition.

The Lodge System.

Before leaving the system in which accumulators or batteries are used, it would be well to mention the device invented by Sir Oliver Lodge.

In describing the Lodge system of ignition, it will be necessary to explain the use and operation of the condenser, because the Lodge system of ignition depends entirely on the use of condensers in the high tension circuit. The condenser is used with all induction coils and with all magnets, so that the reason for its use may well be explained here.

We have pointed out that the spark at the gap depends to a large extent on the suddenness with which electric contact is broken at the contact breaker or the trembler. The condenser is used to increase the rapidity with which the flow of current is stopped, and has also the advantage of reducing sparking at the contacts of the trembler. The current may be considered as having a certain amount of momentum—that is to say, it cannot be stopped suddenly. It is the effect of this momentum which causes it, when contact is broken, to rush across the gap in the spark plug, forming a spark. If this momentum can be absorbed, it is evident that the flow of current will be more quickly stopped, and it is the object of the condenser to absorb the momentum of the current in the primary, or low tension circuit, suddenly, and therefore the condenser is made part of the low tension circuit.

To explain how the condenser is inserted in a circuit, we might take as an instance the wire A B (Fig. 11), along which we will imagine current is flowing. If we put anywhere along this circuit another wire leading from it and returning to it at another point, some part of the current will flow round this second wire, which is termed a "shunt." It is obvious that if we were to suddenly break the metallic current in the wire A B, say at C, the current would flow round through the shunt and get from A to B through the shunt wire. The condenser is arranged in this circuit provided by shunt wire, and is connected anywhere in the primary circuit so long as one connection comes before the trembler and the other comes after. That is to say, the condenser must be arranged in a circuit which will be complete independently of the making or breaking of contact at the trembler.

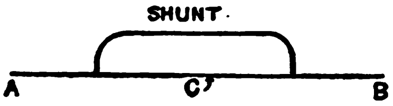


FIG. 11.—A SHUNT.

The condenser will not in itself form a complete metallic path for the current; otherwise it would always flow round through the condenser, and the making and breaking of contact at the trembler would have no effect on the flow of current.

The condenser is formed of alternate layers of conducting and non-conducting material, the conducting material being tinfoil, and the non-conducting material being sheets of paper soaked in paraffin wax, or in some cases sheets of mica are used for the purpose. The use of tinfoil and this paraffined paper or mica provides very large surfaces for the conductors in a very small space.

In Fig. 12 the thick lines indicate the layers of conducting material of tinfoil, and the thin lines represent the non-conducting material which separates them. The alternate metallic conductors are joined together, which is indicated by the fine lines by which we have joined them up. They will be negative and positive alternately, all the positive being joined together and all the negative. Thus, it will be seen that in this arrangement the equivalent of two large plates or surfaces of conducting material face each other, but are insulated from one another by means of the paraffined paper. Suppose A were connected to the positive (+) terminal of some source of electric supply, and B to the negative (—) terminal, the arrangement of the tinfoil would enable the storing up of some of the electric energy, just as physical or mechanical energy—if we may use the term—can be stored up in a spring; and as the spring may be used to absorb the momentum of a moving body, so this condenser may be utilized to absorb the momentum of an electric current.

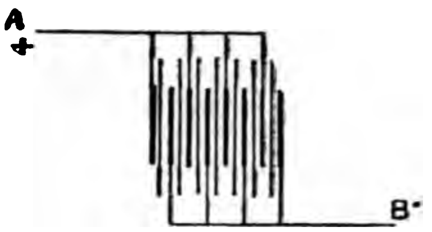


FIG. 12.—DIAGRAM OF A CONDENSER.

Now, supposing that this condenser is put in the shunt circuit, Fig. 11, it gives a loop line between A and B. If the contact is suddenly broken at C, which is done by means of the trembler, the momentum of the current will be absorbed by the condenser, the result being that the stoppage or interruption of the flow of current by the interposition of the air gap at C will be very sudden and without sparking at the contacts. The momentum of the current has been absorbed in the loop representing the shunt by means of the condenser, so that the condenser enables us to get a better spark in the secondary, or, in other words, a more sudden stoppage of the primary current. Thus, the function of the condenser is not only to make a very sudden stoppage of the primary current, but also to stop it without sparking at the contacts of the trembler. Without a condenser there would be heavy sparking at the contacts of the trembler, causing rapid wear.

The condenser is used, as we have said, in every coil and in every magneto machine for electrical purposes, and in some cases, as in the case of some arrangements of De Dion ignition, the condenser is used in the contact breaker, the two ends of the condenser being shunted across the circuit at the contact breaker exactly in the same way as it is shunted across between the trembler points in the case of an induction coil.

In the case of the Lodge ignition the peculiar characteristics of the condenser are taken advantage of to give a very high-efficiency spark; that is to say, the ability of the condenser to absorb the momentum of the current is used in order to get a very high discharge very suddenly, in a similar way to that in which a very rapid discharge of power is obtained from a spring, although the pressure in closing the spring up might be applied slowly and gradually. This is a mechanical action which is taken advantage of in thousands of ways whenever an exceedingly rapid application of power is required. It can be obtained by first slowly compressing a spring and then suddenly releasing it. In the same way, by using a condenser, a considerable amount of electric energy can be stored up, which at the right time can be discharged with considerable rapidity. Sir Oliver Lodge has stated that the discharge from the condenser in the Lodge ignition system takes place in less than a millionth part of a second.

In applying the condenser for the purpose of the Lodge ignition, it is placed in the high tension circuit. An ordinary induction coil is used; that is to say, ordinary as regards the wiring, but specially constructed as regards insulation for the particular work it is to do as far as the high tension circuit goes. This coil is arranged exactly as in the case of other ignition systems we have been discussing. The low tension current induces the high tension current in the secondary winding of the coil, and this high tension current is then conducted, not to the sparking plug, but to the condenser. There is no metallic connection whatever between the high tension circuit, which flows round the secondary wiring of the coil, and the circuit which includes the sparking plug. These are isolated from each other by means of the condensers, as we shall presently explain.

The condensers in this case are not the tinfoil and paper arrangements which are used in the ordinary coil, but consist of what are known as Leyden jars. A Leyden jar is a glass insulating cylinder coated inside and outside with tinfoil. These surfaces of tinfoil, which face each other, but are separated by the glass cylinders, are represented in the ordinary condenser by the tinfoil sheets separated by the paraffined paper or mica.

In Fig. 13 is shown in the very simplest form the arrangement of the Lodge ignition. The high tension current leaves the coils from the terminals A1 to B1, and makes metallic contact with the tinfoil in the two Leyden jars C and D, which act as condensers. From the other tinfoil sheets of the two Leyden jars the current is conducted to the sparking plug across which it will have to jump. What happens is this: as soon as contact is made in the low tension winding of the coil, a high tension current is induced in the secondary winding; as there is no metallic contact, the current is stored up by the Leyden jars or condensers, there being what we might almost term an enormous quantity of negative electricity in one set of tinfoil surfaces and of positive in the other set. This electricity has gradually been stored up during the time that the current is flowing through the primary winding of the coil; but a time will come when so much electric energy will be stored up in the condenser that it will have to find some means of breaking out. It cannot pass across from the negative to the positive surfaces owing to the intervention of the glass cylinders acting as non-conductors, but it will be seen that the circuit from A1 to B1 is nearly joined across at the point A. A is a sparking gap in the open air, and according to the distance of the two balls at A away from each other, so will be the pressure of current necessary to be stored in the Leyden jars before the current will jump the gap and so cause a spark. It will be seen that there is a leak or metallic connection across between C and D. This allows of the lower conductors of the Leyden jars being charged by induction from the upper conductors. When the stored up electric energy in the upper conductors of the Leyden jars reaches a certain point, the bursting pressure will be such that it will discharge across through the spark gap A. This discharge through A takes place with remarkable rapidity, as we have mentioned, but, as soon as it takes place, the stored-up energy on the other side of the Leyden jar surfaces will also be suddenly released, and will then violently jump across the points of the

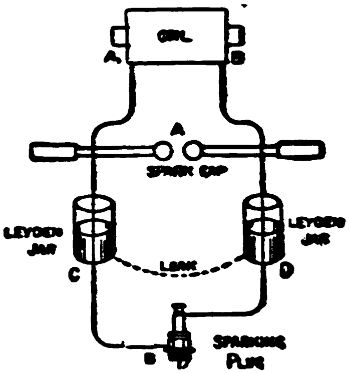


FIG. 13.—THE LODGE IGNITION

sparking plug; that is to say, the positive electricity stored in one Leyden jar and the negative in the other will rush across and neutralize each other.

The characteristic of the sparks at A and B, which sparks have been termed by Sir Oliver Lodge the A spark and the B spark, respectively, is the ability to take the straightest cut even through a gap. Thus, when the discharge of the lower conductors of the Leyden jars takes place it is across the gap in the sparking plug and not through the leak. To quote another description of the Lodge ignition system: "The B spark is an impulsive rush of high pressure current surging across the spark gap with extraordinary speed and energy. A sparking plug that is flooded with oil, one that is wet all over (outside and inside the cylinder), or one that has its spark gap choked all up with carbon deposits—none of these are any hindrance to it whatever. The spark blazes across instantly, blowing all accumulations out of its path, and leaves a clear gap. It is a discharge that must take place somehow. Best of all, it likes a clear and simple metal path, along which it can freely surge, and if it meets a little gap midway—well, it just takes that too—no pause is possible. It has no time to choose a slower path of damp or dirt such as would entice away the ordinary high tension spark. It goes its own way in spite of all, not quietly and easily, but tears explosively over the gap in compression, setting fire to everything combustible it meets; and throwing all else aside."

Another remarkable feature of this particular spark is the ability to use it for clearing away any deposit of conducting material on the sparking plug points. Should the sparking plugs become foul from over-lubrication or other cause, they can be cleaned from the driving seat. The spark gap A is adjustable, and is arranged on the top of the case under a glass lid, which can be easily lifted. By simply screwing the two balls across which the discharge takes place a little further away from each other, the intensity of the spark is then so increased that any accumulations are blown off the points. The spark across the adjustable gap A can be observed through the glass lid of the coil box, so that it can be easily seen whether ignition is taking place correctly, for unless the discharge takes place across the gap A no possible discharge can take place across the spark plug.

The whole of the apparatus is inclosed in a box shown in our diagram, Fig. 14. The spark gap is seen on the top. The current which is given off when the Leyden jars discharge themselves is carried by a highly insulated conductor away to the high tension distributer, which makes metallic contact with the different plugs in proper order. In this diagram it will be seen that there are two tremblers, one on either side of the coil, and these can be easily got at by opening the side doors. These tremblers are both operated by the single iron core of the coil. The low tension current is taken to the top switch shown, and this switch puts the low tension current into contact with one or other of the two tremblers, so that either trembler can be used at the option of the driver. This arrangement is provided so that, in the case of one trembler getting out of adjustment, the other can be used until the necessary adjustment can be made. Although one trembler is only used for the make-and-break of the current, yet the

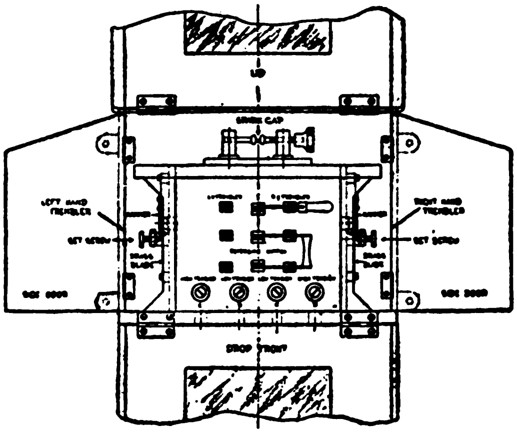


FIG. 14.—GENERAL ARRANGEMENT OF THE LODGE IGNITION APPLIANCE.

rapid alternations of magnetic and unmagnetic state of the core will cause both tremblers to be trembling whichever one is used for the actual making and breaking of the contact.

Another appliance is that for the reversal of the direction in which the current flows through the contact maker. This is accomplished by means of the reversing switch shown, and the functions of this will now be explained. However well made the contact points of a trembler may be, the fact remains that every time contact is broken between them a spark will pass; that is to say, some of the metal will become fused. What really takes place is that particles of fused metal on the positive contact will actually fly across and build up on to the negative, so that the contact surfaces will not keep level. The result is a resistance to the flow of the current and a considerable pitting of the surfaces. The reversing switch allows of the making of either the trembler or the contact screw the positive element in the circuit. It has been found that by reversing the current the metal which is built up on the negative (—) terminal can be actually caused to pass back to what was the positive (+) terminal by reversing the direction of the current; and it is found that by reversing the direction of the current regularly once a day it is only very occasionally necessary to trim up the contact surfaces of the platinum points.

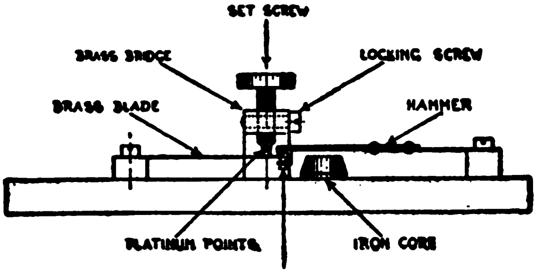


FIG. 15.—THE TREMBLER OF THE LODGE IGNITION COIL

Considerable experiment has been necessary to get out a trembler which should give perfect timing at very high speeds. In Fig. 15 is shown the trembler used. The vibrating mechanism of the trembler consists of two parts—the hammer and the brass blade. The brass blade carries the platinum contact point which makes contact with the point on the end of the set screw. The set screw allows of the adjustment of the two points relatively to each other, this adjustment being locked by the locking screw. The end of the brass blade is held in a stop piece at the end of the hammer. A little rubber stop is inserted in order to take up the impact. The hammer is anchored at one end to the coil case by a spring blade. When the primary current flows across the contact points the iron core becomes magnetized and draws the hammer down. The brass blade being controlled by the stop on the hammer, it also has to move downward with the hammer, and contact is thus broken at the trembler points. The magnetism in the core then ceases, and the hammer resumes its normal position, taking with it the brass blade and again making contact at the contact points.

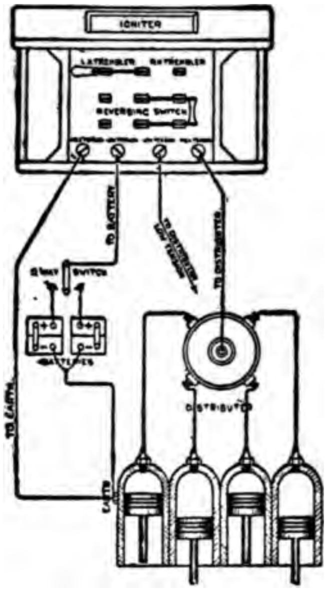


FIG. 16.—THE WIRING OF THE LODGE IGNITION SYSTEM.

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ism of the trembler consists of two parts—the hammer and the brass blade. The brass blade carries the platinum contact point which makes contact with the point on the end of the set screw. The set screw allows of the adjustment of the two points relatively to each other, this adjustment being locked by the locking screw. The end of the brass blade is held in a stop piece at the end of the hammer. A little rubber stop is inserted in order to take up the impact. The hammer is anchored at one end to the coil case by a spring blade. When the primary current flows across the contact points the iron core becomes magnetized and draws the hammer down. The brass blade being controlled by the stop on the hammer, it also has to move downward with the hammer, and contact is thus broken at the trembler points. The magnetism in the core then ceases, and the hammer resumes its normal position, taking with it the brass blade and again making contact at the contact points.

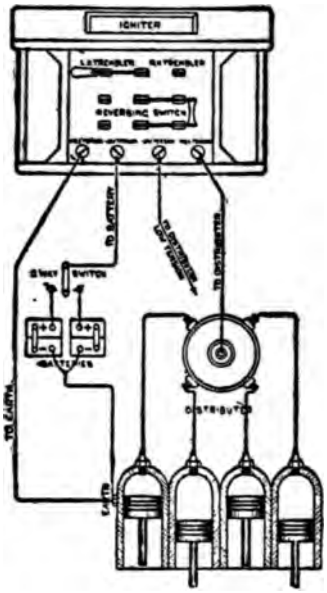
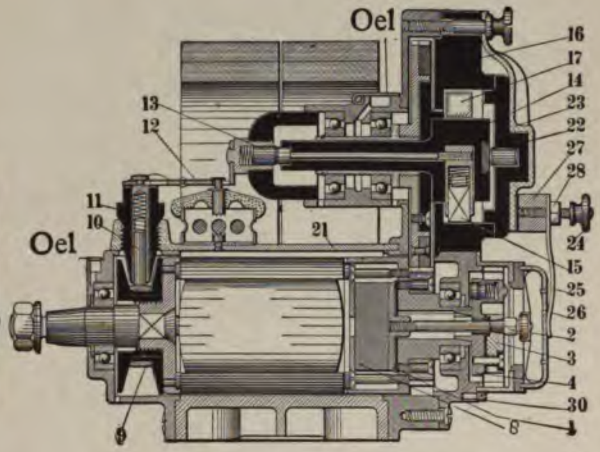
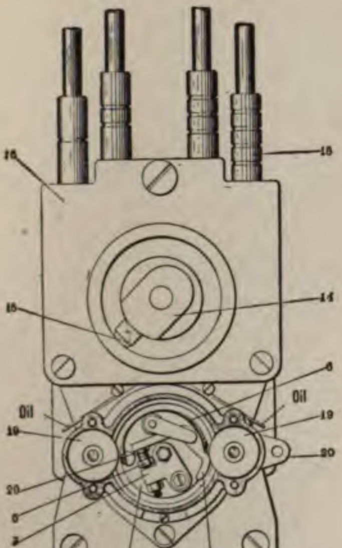


FIG. 16.—THE WIRING OF THE LODGE IGNITION SYSTEM.



Longitudinal Section.

Back View.



1. *Brass plate.*
2. *Contact-breaker screw.*
3. *Platinum screw block.*
4. *Contact-breaker disk.*
5. *Long platinum screw.*
6. *Contact-breaker spring.*
7. *Contact-breaker lever.*
8. *Condenser.*
9. *Slip ring.*
10. *Carbon brush.*
11. *Carbon holder.*
12. *Connecting bridge.*
13. *Contact carbon.*
14. *Rotating distributor piece.*
15. *Distributor carbon.*
16. *Distributor disk.*
17. *Metallic segments.*
18. *Contact plug.*
19. *Fibre roller.*
20. *Timing lever.*
21. *Dust cover.*
22. *Cover.*
23. *Triangular clamp.*
24. *Nut for switch wire (short circuit).*
25. *Spring for fastening brass cap.*
26. *Brass cap.*
27. *Brass block for fastening spring of brass cap.*
28. *Fixing bolt.*
29. *Short platinum screw.*
30. *Stop screw for timing lever.*

Bosch High Tension Magneto—Type DR4.

To understand how this system is wired up, we may refer to diagram (Fig. 16). Two batteries are used, and may be coupled to the ignition by means of a two-way switch. The current is taken by the wire shown to the terminal B on the coil, and then flows through the coil out through terminal C to the low tension contact maker, which in our diagram is called a distributer. In reality, it does not distribute the current, but its function is to make contact every time a cylinder has to be fired. The high tension current is taken from the secondary winding of the coil to the Leyden jars connected up inside the coil case. The high tension current discharge from the Leyden jars is taken from D and E, E being connected to ground and D being connected to the high tension distributer which distributes the current to the different cylinders. It will be seen that the wiring of the system is just as simple as that of any high tension system using a single coil and distributer, the connection of the high tension circuit to the Leyden jars being made up inside the appliance.

THE MAGNETO SYSTEM.

The next of the divisions into which we separate the systems of electrical ignition is the magneto method, and this can be subdivided into two sections, comprising the low tension and high tension systems. In dealing with ignition by dry batteries and accumulators, it will be remembered that we showed that the spark inside the cylinder can be obtained from a low tension current transformed into a high tension current. It is exactly the same with magneto ignition. We may use either a low or a high tension current, but, as in the case of ignition with dry batteries or accumulators, whenever the high tension ignition is used we must have a low tension current to induce it in an induction coil.

In both systems of magneto ignition the low tension current is generated in the same way, the appliances for this differing principally in constructional details and in the method of wiring up, and the high tension system, as far as magneto methods go, in that provision is made to cause the low tension current generated in the machine to induce a high tension current. For this purpose an induction coil, either separately or incorporated in the machine, becomes necessary.

Low Tension Magneto Ignition.

This being understood, it will be well to deal first with the low tension magneto. That once being thoroughly comprehended, the apparent complication of the high tension system will become quite simple. The principle on which the method is founded lies in the fact that if a coil of insulated wire be revolved between the ends of a magnet, the magnetic influence will so act as to cause a current of electricity to flow through the coil, this being of low tension, and being of a nature suitable for ignition either on the low tension system inside the cylinder or to induce a high tension current in some form of induction coil.

The diagram, Fig. 17, shows the permanent magnets used in a magneto. They are of highly magnetized hardened steel, and are generally arranged in pairs, three sets of pairs being used. These are shown at A, B and C. The efficiency of the machine depends in a large measure on the extent to which the horseshoe magnets A, B and C are magnetized. The arrangement of the magnets in horseshoe form is the most convenient for the purpose of getting the coil, which we wish to revolve, well surrounded by the magnet ends, which are for convenience provided with two soft cast-iron pieces D and E in close metallic contact with the ends of the magnets and

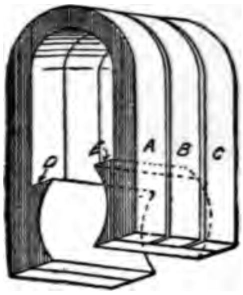


FIG. 17.—THE MAGNETS OF A MAGNETO MACHINE.

forming a kind of tunnel inside which the coil or armature will revolve. These two pieces are termed the field pieces and are often spoken of jointly as the magnetic field.

If a soft iron core of a cross section of the shape shown in Fig. 18 is taken and a winding of insulated copper wire is wound around it as shown in Fig. 19, we shall have a coil which is of a convenient shape to be revolved inside the ends of the magnets; that is to say, it will occupy a position within the magnetic field. The object of having this coil revolving is to cause the magnetic influence, or the lines of magnetic force, as they are termed, of the magnets to pass through the coil alternately from different directions. This core around which we wind the insulated copper wire is known as the armature.

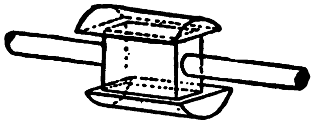


FIG. 18.—THE CORE.

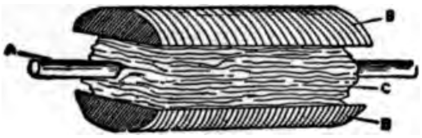


FIG 19.—THE ARMATURE.
A, Armature spindle.
B, B, Iron core of armature.
C. Coil around core.

Fig. 20 is a diagram of the ends of the magnets, and a cross section of the armature in position. AC is the armature core, and C is the winding of insulated wire around it. F and M are the field magnets or permanent magnets, and the south pole of these is at S, the north pole being at N. What effect the position of the armature with its coil, inside the magnetic field will have on it, in an electrical sense, we will next endeavor to explain as simply as possible.

In describing the soft iron core of an induction coil, we showed that, when a current of electricity was passed along a winding of insulated wire around the core, the latter became for the time magnetized. A reversal of this idea may be regarded, for the sake of argument, as what takes place in the case of the magneto. Here there is a soft iron core and the winding of insulated wire around it. If, now, we can make this soft iron core a magnet, we can, in a certain manner, induce a current of electricity in the winding around it, but this depends on the fact that, to get any results from the induced current in the winding, we must keep reversing the direction of the polarity of the core or armature C. In the case of the soft iron core of an induction coil the polarity, that is to say, whether the north pole shall lie at one end or the other, is determined by the direction in which the wire is wound around the core, and is always the same, there being no practical value or advantage in altering the polarity of the core; but in the present case, in order to get an inductive effect, we may re-

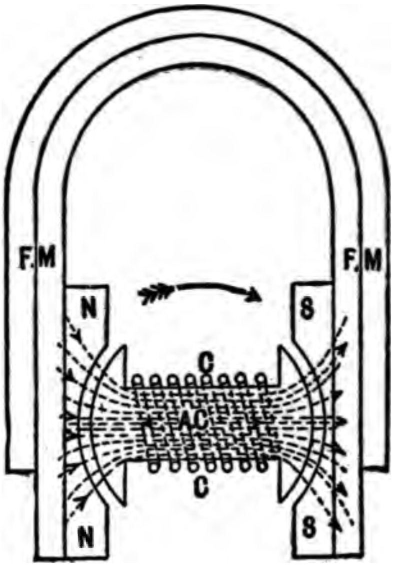


FIG. 20.—LINES OF FORCE PASSING THROUGH THE CORE OF THE ROTATING ARMATURE.

verse the polarity of the core, or we may cause it to intermittently become magnetized, and this can be done by revolving it between the field pieces. The magnet acts on the soft iron core or armature A C, giving it a magnetic pull which is apparent to the touch, if the armature is allowed to move freely towards the field which is trying to attract it. This it can do when the bearings which hold it centrally are dismantled. This force is represented in our diagram by lines, these lines indicating the direction in which the force acts.

The direction of these lines shows us that the magnetic force is similar to electrical force in that it will always try to act in a direction in which there is the greatest body of metal capable of being magnetized interposed between the two field pieces of the magnets. With the core placed in the position shown in Fig. 20 it will be seen that the lines of force are acting as indicated by the dotted lines; that is to say, the magnetic force is acting straight through the center of the armature, and thence through the winding of the coil. Supposing now we rotate the core in the direction of the arrow until it assumes the position shown in Fig. 21, it will be seen that the lines of force have gradually changed their direction. They are still flowing through the greatest body of metal of the core, but they cannot get across in such a direct manner, the direction of the lines of force being indicated by the dotted lines. In fact, there is a kind of leakage, some of the lines of force flowing across between the fields without

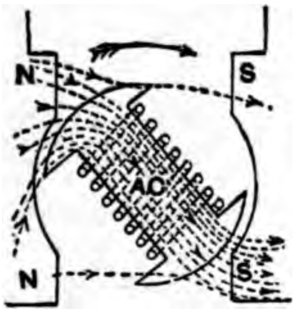


FIG. 21.—LINES OF FORCE IN THE ACT OF BEING CUT.

passing through the armature core, as indicated by the two separate dotted lines.

If the armature is rotated a little further to the position shown in Fig. 22, it will be seen that the lines of force flow across the bulk of metal which forms the sides of the H section of the armature, and do not pass through the center of the armature at all. That is to say, they are not passing through the center of the coil of insulated wire, so that, in fact, stoppage of any magnetic effect on the core has been accomplished by the mere rotation of the core for one-quarter of a revolution in the field. If we rotate the armature another quarter of a revolution in the same direction, it will assume exactly the same position as shown in Fig. 20, but with this important difference, that that part of the armature which was close to the south pole of the magnets now finds itself close to the north pole; so that the direction of the lines of force have been first taken altogether away from the center of the core and then completely reversed relatively to the core itself. It is evident, therefore, that the armature is changing its polarity once every revolution in the field, and it is this constant change of direction of the lines of force through the core that induces the current in the winding around the armature, which current we make use of for ignition purposes.

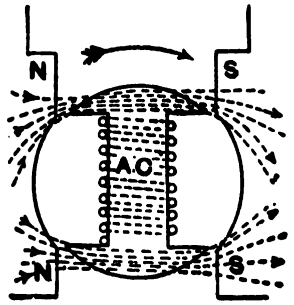


FIG. 22.
LINES OF FORCE PASSING DIRECTLY THROUGH THE ENDS OF THE ARMATURE FROM NORTH TO SOUTH POLE.

As the armature A C wound with the copper conductors or coil rotates between the two poles of the magnet N S it cuts through the lines of force or magnetism which pass from one pole to the other, and as a result a current is induced in the coil of the armature. When the armature rotates through the position as in Fig. 22, it will be seen that the conductors are cutting the maximum amount of lines of force, and, therefore, this is the point at which the current is at its maximum value. As it continues to rotate the current value gradually decreases, and after a quarter revolution (when it is in the position as shown in Fig. 20) when its conductors are, as it were, slipping along the lines of force, and not cutting any, its value is nil. Then it again gradually grows to a maximum in the reversed direction (when the armature is again in position as shown at Fig. 22) and as before, falls to zero, and so on, rising to a maximum and falling to zero twice in every revolution of the armature.

But something else has also been done by this reversal, for it will be found that we have changed the direction of the electrical current flowing through the winding; thus we have an alternating current in the wire. If we were to connect the two ends of the wiring C round the armature, and to rotate the latter at a good speed, we should not get a constant flow of electricity through the wiring, but an intermittent one, that is to say, the voltage of the current would start from zero and gradually rise as the armature revolved and then as rapidly fall. Two of these, which we may call waves of current, take place during each revolution of the armature, and if we break contact in the winding around the armature at the time when the electrical wave is at the highest voltage, we shall be able to get a spark.

It is the object of the low tension magneto system to lead this current generated in the armature winding to the inside of the cylinder and to break the contact there, and if that can be done an efficient spark for ignition purposes is produced.

A Simple Form of Magneto—A very simple low tension magneto system is shown in diagrammatic form in Fig. 23. One half of the magneto has been cut away in order to show the armature A lying adjacent to the field B. The coil of insulated wire around the armature is shown at C, while D is the armature spindle upon which it revolves in bearings fixed to either end of the field pieces, the shaft being driven at one end by a gear wheel which causes it to revolve at some speed relative to the engine speed. It generally runs at half the speed, but, in the case of multi-cylindered engines, it becomes necessary that it should run at such a speed as will give a diversion of the lines of force at least once every time a cylinder has to be fired. One end of the winding of the coil C is directly and metallically connected to the armature shaft, which, of course, grounds it. The other end is brought out and attached to an insulated ring E, which is fixed to some part of the armature or its shaft and revolves with it, but has no metallic connection with it. On the outside edge of this ring, and pressing down upon it, is a carbon brush or wiper F, contained in a tubular case and pressed down by the spring G. The casing which holds this carbon brush or wiper is suitably insulated from any metallic part of the machine, and carries a screw terminal H. It is from this terminal that the current is taken off by means of the insulated wire J and conveyed to the mechanical contact breaker inside the engine cylinder.

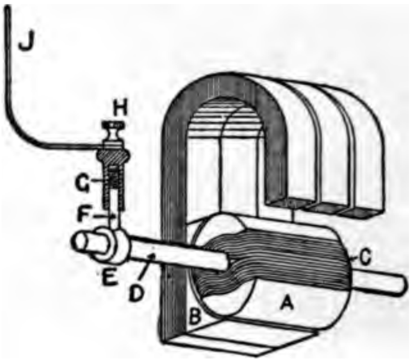


FIG. 23.—DIAGRAM OF A MAGNETO.

The Low Tension Igniter—The contact breaker inside the cylinder for use with this type of magneto is arranged in a variety of different ways, according to the ideas of different designers. Its object is first to keep the circuit open, but just before the armature reaches the position shown in Fig. 26 to make contact, and then suddenly break it when the armature is in the position shown. If contact were made all the time there would be no induction set up in the coil, as may be easily understood by the fact that if we ground the winding to the magneto we stop its operation for sparking purposes. Another point is that in the case of multiple cylinder engines it is necessary that only one contact breaker should be making contact at the same time.

In Fig. 24 is shown one arrangement, by means of which contact can be made and broken inside the cylinder. A is the cylinder in section, so as to show that part of the contact breaker which is inside it, as well as that part which is outside it. Through the wall of the cylinder A passes an insulated plug C, having at its outside end a terminal and terminating inside of a cylindrical piece C1 of steel. This cylindrical piece is insulated from the cylinder by means of the insulation of the

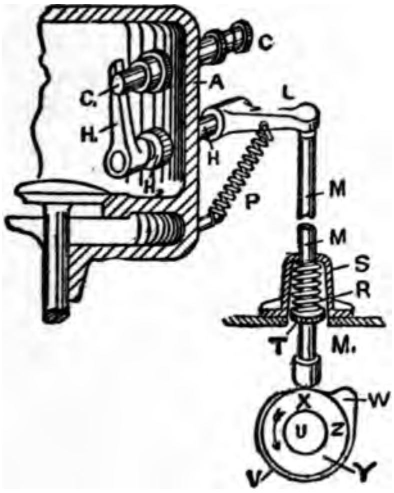


FIG. 24.—LOW TENSION IGNITER.

A, Cylinder.
C, **C_1**, Igniter plug.
H, Rocking spindle.
H_1, Contact arm.
H_2, Conical joint.
L, Lever on H.
M, **M_1**, Tappet rod.
P, Spring.
R, Spring.
S, Thimble over spring.
T, Collar.
U, Cam shaft.
V, Concentric part of cam.
W, Cam projection.
X, Lowest contour of cam.
Y, Cam.
Z, Cam face.

plug. The low tension wire from the magneto leads the low tension current to the plug C. H is a rocking spindle, which also passes through the walls of the cylinder. Inside at H_2 it is provided with a tapered ground joint, so that the pressure inside the cylinder will always keep it gas-tight, yet at the same time it can rock in the joint. On its end, inside the cylinder, it carries a lever H1, known as the contact arm. This lever, as will be seen, is so arranged that it can come up in contact with the insulated plug C1. At its end, outside the cylinder, the rocking spindle H carries a second lever L at right angles to the lever H1. A spring P is interposed between this lever and a pin on the cylinder, and this spring keeps the lever L pressed down, and therefore tends to force the lever H1 in contact with the insulated plug C1. This is the normal position of this lever, except under conditions which we shall next describe.

On the engine camshaft U, which is shown in end view, is mounted an ignition cam Y. The shape of this cam is of importance to the operation of the appliance. There is a tappet rod M which passes through the crank case, and at its end carries a hardened shoe M1. It also has a collar T, and is inclosed partially in a thimble S, which is screwed down on to the crank case. Between the collar T and the top of the thimble S is interposed a compression spring R. Obviously this spring will keep the shoe M1 down into contact with the outside of the cam Y. The top of the tappet rod M is arranged to come just under the end of the lever L. The configuration of the cam Y is such as to give this tappet rod a variable movement up and down. In the position shown the shoe is on that portion of the cam which is concentric with the circle Z, which may be described as the lowest part of the cam. In this position it will be seen that the top of the tappet rod M is not in contact with the end of the lever L, so that the spring P can draw the contact arm H1 into close contact with the plug C1. It is just at this position that contact is made, and is about to be broken. The cam Y rotates in the direction indicated by the arrow, so that, after it has rotated a little farther than the position shown, the shoe M1 is suddenly forced up by the projection W on the cam. As it rises it will also knock the end of the lever L up, and therefore will move H1 out of contact with C1, thus breaking contact and firing the charge in the cylinder. The cam continues to rotate, and the shoe gradually drops again as it comes back upon the lower part of the projection W until it reaches that part of the cam V, which is concentric with the shaft, but of large enough diameter to keep the shoe M1 lifted high enough to keep the lever L lifted up and H1 out of contact with C1. During the rotation of the cam the contact breaker is held in this position until it reaches that part of the cam again when the tappet rod M drops, and allows contact to be made, only to be again broken by the projection W on the cam.

The Fiat Igniter—The illustration (Fig. 24) is purely diagrammatic. A drawing of an actual low tension igniter on practically the same lines is shown at Fig. 25, and the same index letters have been applied to this as in the case of the diagrammatic view, so that the reader can refer from one illustration to the other in order to grasp the details of the arrangement. In Fig. 25, the cam operating the rod M is not shown. It is, however, in construction substantially as illustrated in Fig. 24.

The low tension current is led by the insulated wire F to an igniter or plug G1, made of steel, and passing through the walls of the cylinder. It is insulated from the latter by the two cone insulating collars C and C. By means of the nut E, and the two washers D and D, these two coned insulators can be drawn towards each other, forming a gas-tight joint.

The plug G1 is thus entirely insulated from the cylinder wall, but it is in metallic connection with the insulated coil around the armature of the magneto, through the medium of the insulated wire F. It is necessary in order to complete the circuit for the low tension current that some means should be provided for putting the igniter plug G1 into contact with ground, and at the same time providing a means

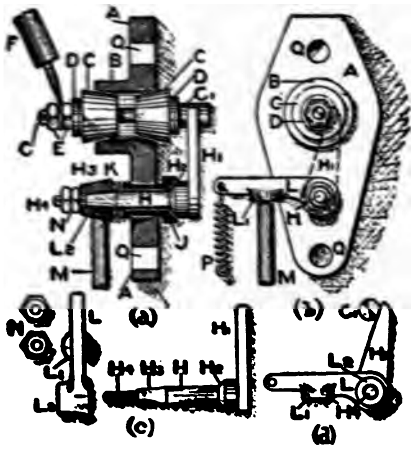


FIG. 23.—THE F.I.A.T. LOW TENSION IGNITION CONTACT BREAKER.

A, A, Plate upon which the ignition device is mounted.

B, Boss bored to take igniter, G, G_1.

C, C, Composition insulating blocks, tapered to form air tight joints.

D, D, Asbestos and brass washers.

E, Nuts for pulling up insulating blocks C, C, and also for attaching the high tension cable F to the igniter G, G_1.

F, Wire from magneto.

G, G_1, Igniter, the end G_1 being larger in diameter than the end G, thus forming a shoulder for the nuts E to pull the insulating blocks up to cover plate.

H, Rocking shaft.

H_1, Contact arm forming portion of H. When contact is broken between H_1 and the end G_1 of the igniter, a spark occurs.

H_2, Conical facing, forming an air tight joint on the seating in bearing piece J.

H_3, Tapered portion of H.

H_4, Screwed portion of H.

J, Bearing piece, in which is formed the seating for H_2.

K, Light spring, keeping H_2 up to its seating in J.

L, Actuating lever, by means of which contact between H_1 and G_1 is broken.

L_1, Small boss or facing, against which the tappet or lifting rod M acts.

L_2, Boss of actuating lever L.

M, Tappet rod.

N, Nuts, screwed on to the end H_4 of H, holding the boss of lever L in position on H by binding it on to conical portion H_3 and by means of which the adjustment of the angle between L and H can be made.

P, Spring attached to the actuating lever L, tending to keep H_1 and G_1 in close contact.

Q, Bolt holes, for attaching the ignition device to cylinder.

for breaking this contact at the moment when firing in the cylinder is to take place.

This is done by means of the arm H1. This arm is fixed at the end of an oscillating spindle H, which passes through a bearing J in the walls of the cylinder. The outer end of this oscillating spindle is provided with a second lever L, this lever being on the outside of the cylinder. It will be seen that if L is lifted or depressed H1 will also be moved inside the cylinder. The top of the lever H1 is brought into contact with the end of the plug G1, by means of the spring P, at the end of the lever L. This spring holds L down and causes H1 to keep in contact with G1. The low tension current from the magneto can then flow through G1, through the lever H, and to earth through the cylinder walls. M is a vertical tappet rod, its bottom end being in contact with the edge of a cam on the engine camshaft.

What happens so far as the mechanical break goes is this: The cam normally keeps M in contact with the boss L1, on the lever L, and keeps this lever lifted just enough to keep H1 out of contact with G1. Just before it becomes necessary to fire the cylinder, however, the cam allows M to drop out of contact with L1, the spring P draws L1 down and causes H1 to be pressed in firm contact with G1. This takes place just at about the time when the armature is in the position shown in Fig. 21 relatively to the field. As the piston comes to within a very little distance of the top of the stroke and just when the relative position of armature is as shown in Fig. 26 (that is to say, the lines of force have just been diverted, and the edge J of the armature has just left the edge K of the field) the cam suddenly forces the tappet rod M upward; thus M strikes L and lifts it, and consequently

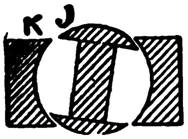


FIG. 26.

breaks contact between H1 and G1. The greatest inductive effect is then taking place in the winding on the armature, and the sudden breakage of the circuit causes the sparking to take place and the gas charge to be ignited.

Very numerous are the mechanisms for breaking contact inside the cylinder, the type we have described being only one of the number. There is one point which ought to be made quite clear. It is obvious that if we had a number of cylinders to fire, say 4, and seeing that all the insulated plugs are in circuit with the low tension wiring around the armature, if the contact between H and G1 were made all the time, and only the breaking were depended on at the time of ignition, it would happen that when one contact breaker in one cylinder was breaking contact, the other might be in contact, with the result that the current would flow through the latter and not jump the gap made by that igniter which had just broken contact. It is, therefore, the function of the cam operating the tappet rod to first put the two into contact, so that the current can flow to ground just a moment before the spark has to take place, and then to immediately break the contact. Normally, in all these appliances, the two conductors are not in contact, so that the device may be very accurately termed a contact maker as well as a contact breaker.

An Emergency Arrangement—In the case of an engine having the mechanical contact breaker inside the cylinder a simple form of stand-by ignition can be adopted, so that in case of any derangement of the magneto the cylinders can be fired in the usual way. In Fig. 27, A is a coil having a soft iron core, and having around this core a considerable winding of insulated wire. The wiring terminates at either end in the terminals B and C, and the current then travels by way of the switch D to the insulated plug in the cylinder at F; the switch D is for the purpose of putting the appliance in or out of operation at will. The current is supplied by the battery G, instead of from a magneto. One terminal of this is connected to the winding inside the coil A. It will be seen that the circuit is from the battery, through the coil, out by the terminal C, to F, the other terminal of the battery being grounded at E. As soon as the engine makes contact inside the cylinder by means of the contact breaker the current flows through the coil, passes across the contact points, flows to ground in the engine, and back to the battery by the battery ground wire E. Just at this moment the engine breaks contact inside the cylinder and a spark occurs. It will be seen that this appliance can be easily fitted up, it only being necessary to connect the coil A to the low tension ignition plugs of all the cylinders. The engine itself, by virtue of the four contact breakers, acts as a distributer, and each cylinder takes its current and breaks contact in its proper order.

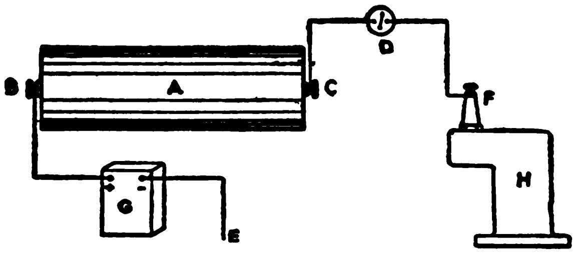


FIG. 27.—A STAND-BY SYSTEM WHICH CAN BE USED IN CONJUNCTION WITH LOW TENSION MAGNETO IGNITION.

A, Low tension coil.
B, Connection to positive terminal of accumulator.
C, Connection to switch.
D, Switch.
E, Earthed connection of accumulator.
F, Igniter plug in cylinder.
G, Accumulator.
H, Cylinder of engine.

A Magnetic Contact Breaker—A new type has been recently introduced by the Bosch company. In this the make-and-break inside the cylinder is operated magnetically. The great advantage of this system is that there is no necessity for specially designing the engine in order to provide tappet rods and other mechanical features to break contact inside the cylinder. The magnetic contact breaker may be screwed into the recess usually occupied by the ordinary sparking plug, and is provided with a low tension current from a low tension Bosch magneto fitted with a contact breaker and distributer.

In our illustration, Fig. 28, we show a cross section of the plug. Referring to this cross section, we see that there is a terminal on the top of the plug to which the wire from the magneto is led, and it is this terminal that takes the current, which is circulated round a winding of insulated wire and around a core situated round a rocking armature. This winding of wire, when the current is sent through it by the magneto, causes the core to become magnetized, and it is the attraction of the armature to it which effects the make and break in the following way:

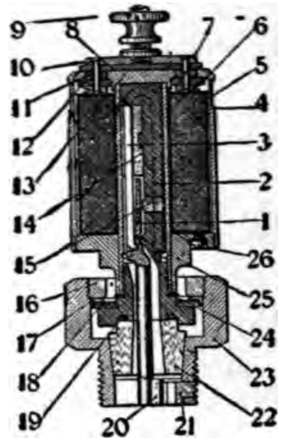


FIG. 28. — THE BOSCH MAGNETIC PLUG IN SECTION.

1 is a lever known as the interrupter lever; it rests on a steel knife edge. At its lower end at 20 it is in contact with a contact piece 21, by means of which it is grounded to the body of the engine. To keep 20 and 21 in contact with each other a U-shaped spring 3, shown partly in outline and partly by dotted lines, is used. It will be seen that one end of this U-shaped spring rests in a recess just below the point at which the interrupter lever is pivoted on the knife edge. Only a very slight movement of the spring is

necessary to keep the two contact points 20 and 21 in contact with each other. The upper part of the interrupter lever 1 forms the armature, and the central part upon which it is pivoted on a knife edge forms a pole piece, but it must be understood that the interrupter lever is insulated from the pole piece of the electro-magnet formed by the coil 5. Normally, the U-shaped spring presses the interrupter lever 1 in contact at 20 and 21, thus grounding the magneto. At the time of sparking a current flows through the coil 5; this energizes the pole piece 2, with the result that the top part of the interrupter lever is drawn toward it, its bottom end thus breaking contact between 20 and 21. The top of the interrupter lever is not allowed to touch the pole piece 2, and is insulated magnetically by means of a small brass separating piece 15, up against which it is pulled when contact is broken. The magnetic pole piece 2 is purely for the purpose of being magnetized by the coil 5, and it is not in metallic contact at all with the body of the plug 23, which is screwed into the top of the cylinder. It is insulated from it by a tapered plug of statite 22 and by mica washers 18, secured in position by means of the packing collar 16.

In order to follow the wiring, it must be understood that the low-tension current from the magneto is taken to the terminal 9. This is insulated from every other part of the plug except the ring 6, from which the current is taken to the coil 5, and is grounded from the coil by means of the screw 26, which is in metallic contact with the metal part inside which the armature is carried. It thus allows the current to flow through the interrupter lever 1 and to ground in the body of the plug 21, but the moment it commences to flow the coil 5 becomes energized, magnetizes the central core or pole piece 2, draws the armature or interrupter lever toward it, and breaks contact across between 20 and 21.

The magneto which is used in conjunction with this plug provides a low tension current only, but it is provided with a distributer which will distribute the low tension current to each of the magnetic plugs in turn. It is also provided with a contact breaker, which will break contact each time the current has to be sent through one or other of the magnetic plugs. The advantage of the system is also shown in the fact that no high tension wires necessitating thick insulation are required, while spare plugs may be carried in case of any damage to, or derangement of, the plugs in use. It is necessary, however, that the plugs should be kept in as cool a position as possible on the engine. The contact between 20 and 21 is a V, and there is some sideplay allowed on the interrupter lever, so that should one side of the contact become charred or carbonized it will be automatically forced to the other side and make contact. Experience has shown that in this respect the plug contacts are practically self-cleaning.

High Tension Magneto Ignition.

All that we have said under low tension magneto about the revolving armature in the field holds equally good as regards the high tension device, but in this case the low tension current generated in the armature is used to induce a high tension current in an induction coil, the current being used to jump across the gap in an ordinary sparking plug, doing away with the necessity for any contact breaker inside the engine. The magneto appliances in this system vary a great deal in minor details, especially as regards the mechanision current from the armature is sent to an induction coil of the ordinary type, which may be placed in any convenient position on the car, and is really a separate and complete appliance independent of the magneto. We may quote two examples, the Simms and the Eisemann, and a description of these will be sufficient to enable the reader to grasp the principle on which all these machines are constructed.

The Simms high-tension magneto utilizes the low tension current in the armature itself to induce the high tension current in a second winding around the armature. The armature thus fulfills the double purpose of producing the low tension current which, in turn, induces the high tension current for firing purposes. It will be seen that in this case the armature is a complete induction coil in itself, having its primary and secondary windings and its soft iron core. The appliance also incorporates the high tension distributer, so that it is a complete electric ignition system in one unit, and only requires to be coupled up to the engine.

In the case of the Eisemann ignition the magneto only supplies the low tension current, there being but a single winding on the armature. This current is then led away through the primary winding of a separate induction coil which induces the secondary or high tension current for sparking purposes. In this type, in addition to producing the low tension current, the machine also acts as a snychronized distributer, the high tension current from the induction coil being led back to the magneto and from that distributed to the different sparking plugs in turn. The advantage of this system, as we shall presently see, is that the production of the low tension current, and its sudden break or interruption, and the distribution of the high tension current induced in the coil to the plugs in turn, are made to take place absolutely at relative times to each other under all conditions. Hence where we have the magneto generating the high tension current to jump across the ordinary sparking plug, we must have a separate contact breaker for the low tension current. Of course, in this case we need no contact breaker inside the engine; the magneto is, therefore, provided with a contact breaker, forming part of its mechanism, the function of which is to break the contact in the low tension circuit.

Before proceeding to describe the working of the high tension magneto, we might say that there is another system in which, like the Eisemann, the magneto generates only the low tension current to induce the high tension current in a separate coil; but in this case the magneto does not act as a high tension distributer, this function being performed by a separate part of the engine mechanism. As an example of this, we have the De Dion system. In this there is simply a rotating armature in a magnetic field with a low tension winding upon it. The current from this is led to a [illegible] is [illegible] by a con-[illegible] on the magneto and forming part of its mechanism. The high tension [illegible] generated in the coil is then [illegible] to a high tension distributer on the magneto and distributed to the sparking plugs in turn. The advantages of this system are a simplification in the magneto and great facility in employing a dual system of ignition. By using the contact breaker and the distributer on the magneto and the coil as well, a separate ignition system in which the current is generated by a dry battery.

The Eisemann System.—In this system the low tension current is taken away from the magneto and used to induce

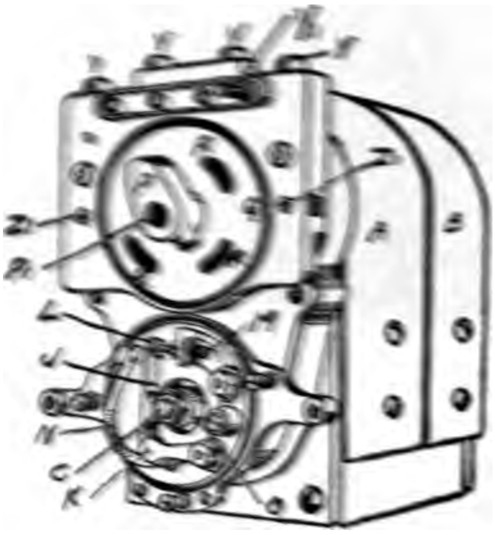


FIG. [illegible].—FRONT VIEW OF THE EISEMANN MAGNETO.

a high tension current in the secondary winding of an induction coil. This high tension current is then brought back from the coil to be distributed by a distributer forming part of the magneto mechanism. There are several types of this magneto used; they vary generally in their mechanical details, but in principle are all practically alike. In the first place, as regards the armature, this runs on ball bearings in plates affixed to the end of the field pieces, the plates being of some non-magnetic metal. A front view of the machine is shown in diagrammatic form in Fig. 29. The magnets are shown at A and B, and the armature revolves inside between the ends of these, the end of the armature shaft being seen at C. If we look now at Fig. 30 we shall understand how the different units of the magneto are built up. C is the end of the armature shaft. The latter revolves in ball bearings in the end plates and carries the wheel D; this wheel gears with the second wheel E, which is mounted on a second shaft carried in bearings inside the space formed by the horse-shoe magnets A, B. The rotation of the magneto armature will rotate E at half the speed of the shaft. It is the function of E to act as a high tension distributer in a manner which we shall describe later. The contact breaker is mounted on a plate shown in Fig. 29, and consists of a pivoted arm J which is pivoted at K, and is L shaped. At its top end it has a small platinum-pointed head L which

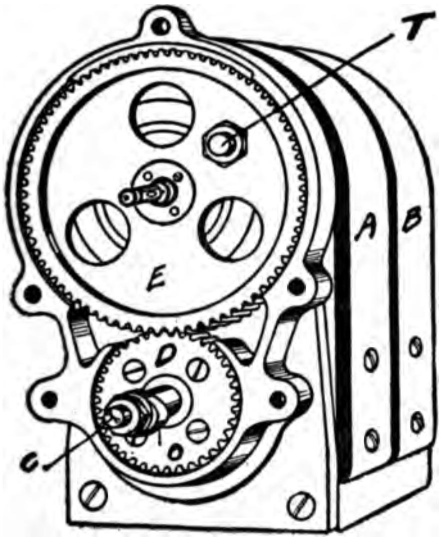


FIG. 30.—THE GEAR WHEELS WHICH OPERATE THE HIGH TENSION DISTRIBUTER.

comes into contact with the platinum-pointed contact screw M, capable of adjustment, and to which the current is led from the primary winding of the magneto armature. A spring N keeps the pivoted lever J pressed up so that contact is made between L and M. On the end of the armature shaft there is a cam O. (This cam is seen more clearly in Fig. 30, where it is not confused with the mechanism of the contact breaker.) Now, at the time that the armature is just cutting the lines of force in the magnetic field, this cam comes up against the lever J and knocks it out of contact with the insulated contact screw M, so that the circuit is broken at this moment.

The current from the low tension winding is taken through an insulated contact piece C on the end of the armature shaft, and passes to a carbon spring brush on the cover of the contact breaker, and from there to the platinum screw M of the contact breaker. This carbon brush is also connected to the primary winding of the coil. Thus normally the path of the low tension current is through the contacts of the commutator to ground, through the cam O and the armature, which is connected to ground by a spring-pushed contact piece, not shown in our illustration. This is really to insure a thorough contact to ground. At the moment of breaking the contact the current passes from the carbon brush to the low tension winding of the induction coil and then to ground.

The high tension current is now generated in the separate coil, and is returned by means of the insulated wire to the high tension distributer, also part of the magneto. This is shown very clearly in Fig. 30. At the end of the shaft, on which is mounted the wheel E, is mounted a rotating arm P (Fig. 29). This arm is insulated from the shaft and to it is conveyed the high tension current from the coil. It is the object of this rotating arm to distribute in rotation the high tension current to the different cylinders, which it does in the following way. The current is led to it by means of a terminal Y2 on the cover, which is shown in Fig. 31. This cover encloses the high tension distributer. The two spring fasteners Z, Z engage in the holes Z1, Z1 (Fig. 29). In the center of the cover, Fig. 31, is shown a spring-pushed contact piece G pressed forward by the spring G1. This is insulated from the cover, but is in metallic contact with the terminal inside Y2. When the cover is in position, G presses up against the contact piece P1 (Fig. 29), in the rotating arm P, and thus the high tension current is led to P, which revolves in front of an insulated disk Q. In this disk are inserted four segments R, R, R, R and a spring-pushed wiper inside the end of the arm P, and pressing against the vulcanite disk Q, makes contact with each of these four insulated segments in turn. These segments are internally connected up to terminals Y, Y, Y, Y on the top of the plate S, and from these terminals wires run to the different sparking plugs. It will be seen that this arrangement will distribute the current alternately to each of four cylinders. In the case of a two-cylinder engine or a six-cylinder engine there would have to be two or six respectively of these insulated segments, and in the case of a six-cylinder engine the ratio of gearing between the magneto and the engine would have to be differently arranged so as to give one make and break of con-

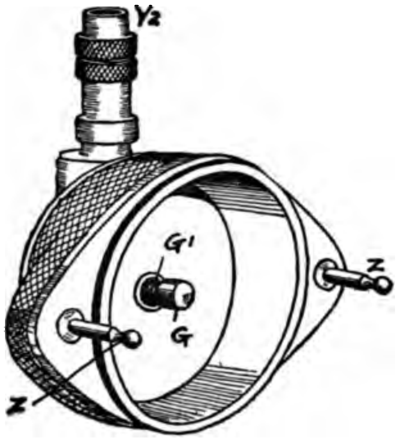


FIG. 31.—THE COVER OF THE HIGH TENSION DISTRIBUTER.

tact in the low tension contact breaker every time a cylinder had to be fired.

In addition to distributing the high tension current from the coil, this device is also used to distribute the high tension current from a trembler coil where an accumulator and coil ignition is used in conjunction with the high tension ignition, and for this purpose a wiper T (Fig. 30) is arranged in the face of the half-speed gear wheel E, which also makes contact with the four segments, and distributes the high tension current from the accumulator ignition system. This is accomplished as shown in Fig. 32. Here we have the insulated distributer disk Q with four distributing segments R1, R1, R1, R1, but we are now looking at the back of the revolving disk. The wiper T in the wheel E (Fig. 30) as it revolves presses against the back of the distributer disk and makes contact alternately with the four segments. All the four segments are connected to a terminal Y1 (Fig. 29), and this terminal is connected to the primary winding of an independent trembler coil provided with current from an accumulator. It will be seen that current from the accumulator will flow through the primary winding of the coil and pass

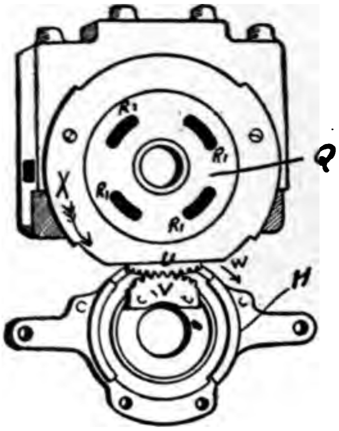


FIG. 32.—THE TIMING ARRANGEMENT OF THE EISEMANN MAGNETO.

along through Y1 to the four segments R1, R1, R1, R1, and every time the wiper in the wheel E comes round and makes contact with any one of these segments the current will flow to ground through the mechanism of the magneto itself.

This, of course, is an entirely distinctive function in the magneto, adopted especially to allow of its being used as a part of a dual ignition system, so that the distributer on one side acts as a high tension distributer and on the other side as a low tension wipe contact maker. The high tension distributer is used for both systems to distribute the high tension current to the plugs, the current being led either from the trembler coil or from the plain coil as may be determined by the position of a two-way switch. This switch is also arranged to put the magneto out of operation when the accumulator ignition is being used; that is to say, it short circuits the low tension current of the magneto to ground all the time, with the result that no inductive effect is taking place in the coil (for it must be remembered that it is only when the current is broken in the primary that the inductive effect takes place in the secondary).

One other feature of the arrangement remains to be described. It becomes necessary in the case of high tension ignition that the time at which the spark shall take place can be varied within certain limits relatively to the position of the piston in the cylinder. When the engine is running slow the time of breaking contact should be retarded, while when it is running fast it should be advanced. The reason of this is that the lag set up in the coil, due to the appreciable time which it takes the low tension current to energize the secondary winding, would cause the engine to fire too late if it were running fast. The time interval as regards the lag in the coil is constant, but the time interval between the piston assuming a position ready for firing at the top of the cylinder and having advanced a little way down the cylinder is inconstant and varies according to the speed.

In the Eisemann ignition appliance, for example, there are three ways of altering the time at which contact shall be driven by the armature spindle relatively to the engine, and there are at least 2 different types of these machines which it is unnecessary to differentiate between here. In the first case the shaft which drives the armature spindle is connected to the driving part, that is the part which the engine drives in the manner shown in Fig. 3. This plan is not adopted in the particular type we have been describing, but in another type. Here B is the shaft driving the armature A: S is the wheel geared to the engine and runs always at a speed varying with the varying speed of the engine: this wheel is mounted on a sleeve B2, and this sleeve has in it a straight

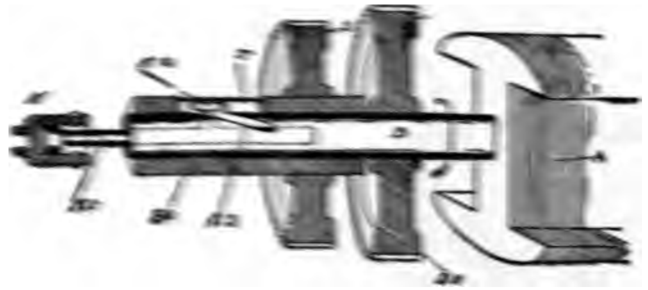


FIG. 4.—HIGH TENSION MAGNETO—THE TIMING SYSTEM

slot T parallel with its axis. The spindle B similarly has in it a helical slot K3, and through this slot protrudes a pin K2, which can move helically in the helical slot and laterally in the parallel slot. The pin K2 is rigidly fixed in a sliding bar K1, which can slide in a hole in the end of the armature shaft B, and can be pulled in and out of this hole by a swivel K attached to a convenient lever on the car. It will be seen that by pulling out or pushing in the rod K1 the wheel S will be caused to rotate slightly on the armature spindle B, thus the position of B relatively to S can be varied within the limits of the angular movement of K2 in the helical slot K3. If the shaft is rotating, in the direction of the arrow, pushing in the rod K1 will advance the ignition, while drawing it out will retard it. In this diagram D8 is the wheel which drives the distributer shaft, which is somewhat differently arranged from the model which we have been describing and is driven from the rear instead of from the front. It is obvious, of course, that both the low tension contact breaker and the high tension distributer should be retarded equally and simultaneously. In the case we have described, this is done in a very simple manner.

Now, as regards the later type of Eisemann magneto, the advance and retard is shown in Fig. 32. The plate H which carries the contact breaker is capable of a slight oscillating movement around the armature shaft bearing in either direction as shown by the arrows. It will be seen that at U there is a segment of a toothed circle engaging with the segment of another toothed circle at V. It is obvious, of course, that the armature shaft is revolving in the opposite direction to the shaft of the high tension distributer; therefore, in order to advance them both together they must be oscillated in opposite directions. This toothed segment U forms part of the distributer disk Q, in which are recessed the insulated segments R1, R1, R1, R1. By slightly rotating H in the direction of the arrow W the insulated disk of the distributer Q will be partially rotated in the direction of the arrow X. Thus both will be equally advanced or retarded relatively to the position of the cam on the armature shaft. Although this will advance and retard the ignition relatively to the engine position, it will not have advanced or retarded the armature relatively to the engine position, so that sometimes the break in the low tension circuit will take place earlier and sometimes later than the ideal position in which the best inductive effect is taking place in the winding of the primary coil. The high tension wires from the high tension distributer are taken from the terminals Y, Y, Y, Y (Fig. 29), these being separately connected to the insulated segments.

There is still another way by which the advancing and retarding of the magneto relatively to the engine can be accomplished, and that is by bodily rocking the magneto magnets and pole pieces themselves around the armature. This method, and the method which we first described, with the vertical dot are the correct ones, because not only is the contact breaking and the distributing advanced or retarded relatively to the engine, but so also is the actual position of the armature, with the result that contact is always broken at the best position of the latter, however advanced or retarded the ignition may be.

We may now deal with the wiring of this system, which is shown in Fig. 74. Here on the left we see the magneto, and on the right the coil box containing the two coils, one coil being that used in the magneto and having no trembler, the other being an ordinary coil with a trembler for use with the storage battery.

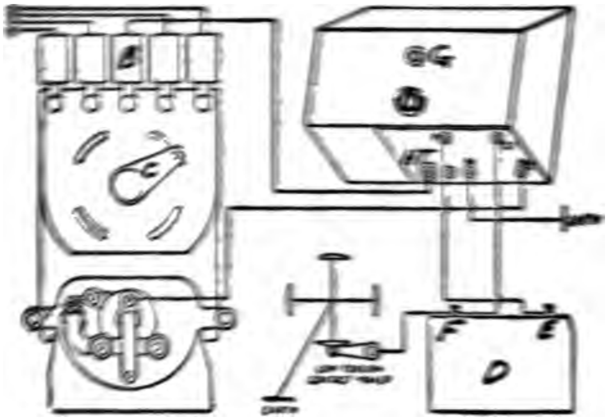


FIG. 74—DIAGRAMMATIC VIEW OF THE WIRING OF THE EISEMANN MAGNETO IGNITION.

Let us take first the winding of the magneto. From the terminal on the magneto contact breaker the current is taken by the wire indicated to the terminal M2 on the coil. It flows through the primary winding of the coil, and is taken out at M to ground which completes the low tension (earth) circuit of the magneto. The high tension current leaves the coil at HT and goes to the terminal B on the magneto, this being the terminal which conducts the current to the central wiper C of the distributer, from which it passes alternately from one of its terminals E to the terminal P on the trembler and so to the plugs. This is the complete circuit, both high and low tension, for the magneto ignition.

The accumulator or battery is shown at D, and a wire is led from one of its terminals E to the terminal P on the trembler coil. It thus passes around the primary winding of the coil, and is taken to ground from terminal M, the ground terminal M being common to both coils, as also is the high tension terminal HT. From the other terminal F of the accumulator the current is led to the low tension contact maker. This device is, for the sake of clearness, shown separately in this diagram, but it will be understood that it is the device which we have illustrated as forming part of the high tension distributer on the magneto. As the segments alternately come into contact with the contact maker, they ground the current as indicated; it will thus be seen that the current has a complete circuit starting at ground, through the coil to the accumulator, to the low tension contact maker, and from that again to ground. The high tension current being induced in the second coil is conducted by the common high tension terminal HT to terminal B on the high tension distributer, and is distributed as before to each plug in turn. In this diagram it will be noticed that there is one wire which we have not mentioned, and it would look as though this wire would make a complete circuit between the coil and the accumulator without the need of the high tension contact maker. This wire runs from F to ST, but its only object is to enable the driver to pass a spark through the plugs whatever the position of the low tension contact maker. This is done by means of a small push button switch G on the coil. This switch puts ST into communication with the primary winding of the coil, so that there will then be a complete circuit from E to terminal P on the coil, out from the coil, through the switch G, and back through ST to terminal F. The effect of this is that as soon as the switch C is pushed and released suddenly, a current is sent through the primary winding of the trembler coil, with the result that that cylinder is fired which happens to be in the circuit through the high tension distributer—

an arrangement which allows, when the engine is warm, of starting it from the switch without having to rotate the crank-shaft.

The Simms Magneto System.—In this the magneto performs the whole of the functions relating to the ignition, and the apparatus for doing this is contained in one complete machine. The low tension current is generated in the armature, and its circuit is broken at the contact breaker. This induces the high tension current in the secondary winding of the armature, and this is distributed by a distributer, all four appliances being arranged in the one machine. This is a type specially made for firing four-cylindered motors, and is a recent type of the Simms magneto. In Fig. 35 we have diagrammatic views of the end of the machine with the covers removed, and also a cross-section of the machine. A is the armature spindle, and B is the armature with a winding around it of thick insulated wire at C, and a secondary wind-

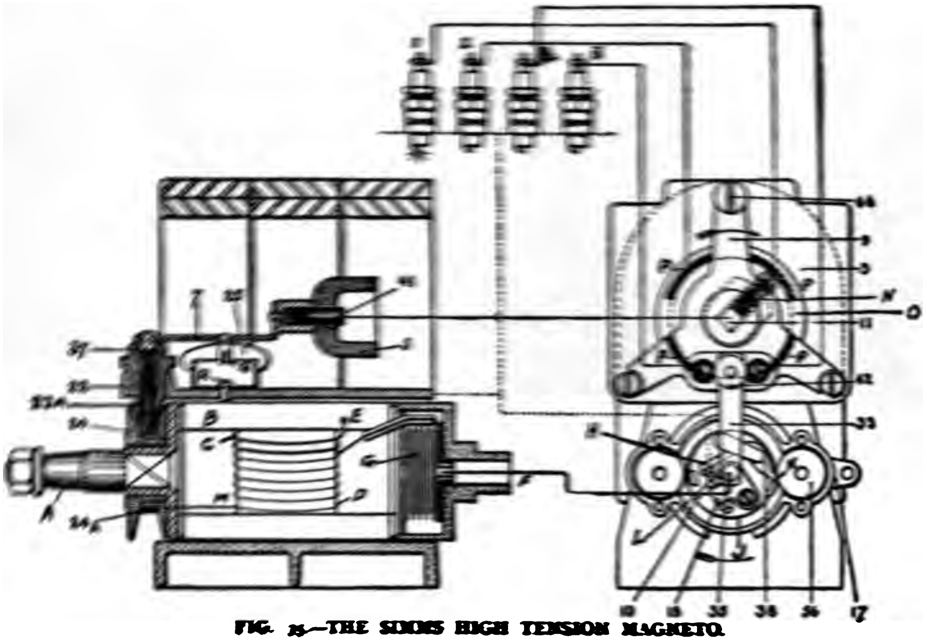


FIG. 35.—THE SIMMS HIGH TENSION MAGNETO.

ing of thin insulated winding of a great number of turns at D. In our diagram these windings are shown alongside each other and without many turns; this is for the purpose of simplicity in following out the arrangement of the winding rather than actually indicating how it is put on. As a matter of fact, the thick insulated wire is wound round the armature for several rows, and the correct length of thin insulated wire is wound round outside this. The thick insulated wire C forms the primary winding, and in it, by the rotation of the armature (as we have already described) within the pole pieces or fields, is induced the primary current for the coil. This primary current is grounded directly to the metal of the armature at E, its other end being carried out, as shown, to the end of the armature, where it emerges at F. In a shunt between C and F on this primary circuit is situated the condenser G, which is contained in one end of the rotating armature. The diagram on the right-hand side gives the end view of the appliance, and shows that this wire is led to a contact breaker situated at the end of the magneto machine. This contact breaker is shown at 10, and rotates with the armature. In rotating, a pivoted L-shaped lever 38 is forced by a spring up against an outside fixed ring J. The end K of the lever, as it rotates, comes in contact with two rollers, one on each side of the contact breaker, one of these rollers being marked 56. It will be seen that as it strikes these rollers its far end H will be lifted. H has at its end a platinum point which is normally in contact with another platinum point at L on a piece 18 (insulated from the magneto), so that every time it strikes one of the rollers during its rotation it will suddenly break contact between the points at L, the points being kept normally in contact by means of a spring. The low tension current which runs through the wire F is carried to the part 18 of the contact maker, which is insulated, and when contact is made across the points at L the current flows to ground through the lever 38. The make-and-break of contact here occurs twice during each revolution. It will be seen, therefore, that the low tension current has a complete metallic circuit every time contact is made across the points L, and, when interrupted, induces the high tension current in the secondary winding.

The condenser, which forms part of practically every magneto machine of the high tension type in which a separate coil is in use, is, as we have seen, formed on a shunt on the low tension circuit. The object of the condenser we have already described when setting forth the principle of the Lodge ignition. The primary winding being now quite clear, it is necessary to consider what happens in the high tension circuit, which is induced each time the contact is broken in the low tension circuit, that is, twice during each revolution, it being understood that contact is broken when the armature is in a position in which its edge has left the edge of the field piece by about 1.5 mm.

To follow this circuit we shall have to refer now again to the diagram on the left in Fig. 35. It will be seen that on the armature there is a kind of pulley 24. This pulley is of insulated material, but it carries in the bottom of its groove a metal ring 24A. If reference is now made to the secondary winding D (shown by the fine lines), it will be seen that the wire is led out at M through to this insulated ring in the pulley 24. The other end of the secondary winding is grounded, as in the case of the low tension winding, to the armature itself. Now, at 22 is seen a carbon holder. This carbon holder is of insulated material, and inside it slides a carbon pencil 22A. This pencil is pushed down on to the insulated ring 24A by a spring 37. It is this carbon brush or pencil which picks up the high tension current from the revolving armature through the medium of the revolving insulated ring 24A. The high tension current is then led along a conductor bar 7 to an insulated cup holder 5, having inside it another spring-pushed carbon pencil 41. It is by means of this connection that the current is conveyed from the high tension winding in the coil to the distributer, which we shall next describe.

The distributer is seen more clearly in the right hand of the diagram. The line shown leading from the carbon 41 indicates that the piece 11 is in metallic contact with it. This piece 11 is fixed in a revolving insulated holder, which is rotated by means of a gear wheel on the armature shaft, and revolves at a speed relative to it. It also contains a spring-pushed carbon point N. This is pressed up to a ring O, in which are recessed four metallic segments P, P, P, P. Each of these segments is electrically connected by wire to one of the sparking plugs, as shown. It will thus be seen that as the distributer rotates it will distribute the high tension current to each plug in turn.

There are two other parts of the mechanism which it is necessary to explain. We have shown that that part of the contact breaker marked 18 is insulated from the rest of the machine, and that to it is conducted the wire from the low tension winding. There is a metallic cover arranged to cover the contact breaker, and this metallic cover lics in a circular groove in an insulated ring, so that it is not in metallic contact with the magneto. It is pressed down into position by the spring blade 33, which is anchored on an insulated plate and held down by a terminal screw 42. This spring blade performs a double purpose. It holds down the cover of the contact breaker firmly in position to exclude dust, and it makes metallic contact with the insulated part 18, because inside the cover is a spring blade with a little carbon point or brush, which presses on the screw 35 in the insulated piece 18. From the terminal 42 a wire is run to a switch, by means of which the current may be grounded. This switch is generally arranged on the steering wheel or steering column. When the switch is turned so that the wire is put into metallic contact with the car, the low tension winding, it will be seen, is grounded at both ends—at one end to the armature at E, as we have shown, and at the other end to the car, so that the contact breaker becomes inoperative as far as breaking contact, and no inductive effect takes place in the secondary winding. By simply grounding the low tension circuit to this switch, the magneto is put out of operation and the engine stopped, nor can it be started until again the switch is opened.

On the left diagram in Fig. 35 will be seen on the conductor bar 7 a dome-shaped piece 25. This is of porcelain, and it will be seen that it carries at its center inside two points Q and R. Q is in metallic contact with the conductor bar 7, carrying the high tension current, while R is in contact with the frame of the magneto itself. The object of this is to form a safety gap, for should at any time the high tension circuit be interrupted, as by the falling off of one of the wires from the sparking plug or from its connection with the magneto, the sudden rise of electrical pressure in the secondary winding might cause the insulation of adjacent layers of the winding to be broken through by the current sparking across through the insulation of the adjacent windings of wire. In order to prevent any accident of this sort, this spark gap is put in, and should the secondary current be, as we have mentioned, interrupted and the electrical pressure in the secondary winding rise too high, it will discharge itself across the points Q and R, and so save the insulation of the secondary winding from damage.

In case any misunderstanding should occur in the mind of the reader, it is well to point out that in the left-hand side of the diagram the distributer mechanism, the contact breaker, and end plates which assemble the whole machine together are left out. They are shown, however, separately on the right-hand side.

We can now trace the wiring of the high tension current. Leaving the armature coil at M, it is picked up from the ring 24 by the carbon wiper 22A. It is conducted along the brass conductor bar 7 to the carbon brush 41. It is there picked up by the carbon brush N and distributed to the segment P, which in our illustration happens to be the one which is opposite the distributer. From P the current is led by an insulated wire to sparking plug No. 1. It will be seen that in the position shown the end K of the L-shaped lever of the contact breaker has just commenced to break contact. It is rotating in the direction of the arrow, and has just commenced to lift by coming in contact with the roller 56. The distributer, which rotates in the opposite direction, has come opposite a segment in circuit with No. 1 plug. The current jumps across the spark gap in the plug and to earth. A similar circuit would be followed if the distributer brush were opposite any other of the four insulated segments in the distributer, but of course they would lead to different plugs. The return ground circuit is shown by the dotted lines. It will be seen that this very ingenious arrangement of the whole mechanism in one unit necessitates only the four well-insulated wires from the magneto to the sparking plugs.

See illustrations of the Bosch magnetos.

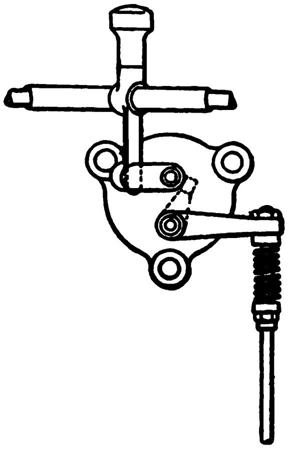
A Typical System of Ignition.

The make-and-break system of ignition used on one of the best known American cars for several seasons is thus described:

"The advantages of the make-and-break system of ignition are very numerous; in the first place, the alternate contact and separation of the electrodes make it possible to use the simple primary electric circuit and the low tension magneto, the simplest instrument from which electricity can be generated. Also, owing to the simple character of the electrical problem, the weight of batteries, coil box, commutator and high tension wiring is saved, together with any troubles which are ever experienced with these devices. With the make-and-break system of ignition there is a remarkable freedom from "missing," or irregular action, and in case any difficulty does occur, it can be located immediately, and corrected without difficulty. Also, and very important, the hot strong spark produced gives more power, according to the makers' experiments, than can be obtained by any other system of ignition on the same motor.

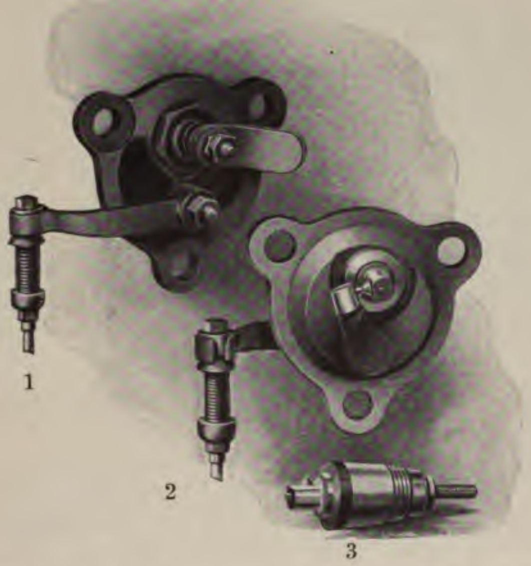
"The operation of the make-and-break system is in any case very simple, but on the car in question the number of parts has been reduced to a minimum and every precaution has been taken to prevent wear and to obviate any unnecessary adjustment.

"By consulting the photographic illustration 'Parts of a Typical Make-and-Break System of Ignition,' it will be noticed that Figure 1 shows the outside of a complete left igniter, one of which is secured to the corners of each of the cylinders. Figure 2 shows the inside of this igniter, with the hammer and anvil in contact; Figure 3 shows the anvil, or fixed electrode, withdrawn entirely from the igniter plate. The upper end of the tappet rod is hooked on to the end of the hammer lever at 'H,' so that as the tappet rod is given vertical motion by one of the cams and rises, the hammer comes in contact with the anvil and stays there until the cam has reached such a position that the tappet rod suddenly falls, causing the hammer to separate sharply from the anvil and the spark to occur, the action being assisted by a strong enclosed spring at the bottom of the tappet rod. It will be noticed also that there is a spring at the top of the tappet rod, the purpose of which is to maintain enough pressure on the end of the hammer lever to maintain contact between the electrodes until it is time for the break to occur.

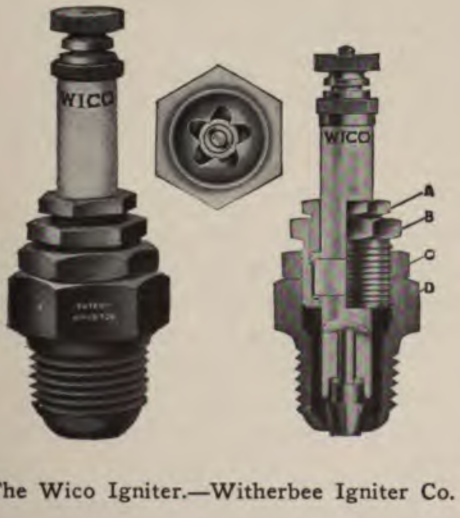


Outline of Right Igniter

"The contact surfaces are of iridium, a globule of which



Make-and-Break Igniter of the Locomobile System.



The Wico Igniter.—Witherbee Igniter Co.

is securely and permanently fastened to the hammer and to the anvil, an arrangement which prevents burning or wearing down of the contact surfaces and which consequently renders any timing of the motor unnecessary except at infrequent intervals. The anvil, or fixed electrode, is made in one solid piece having a cone fit through the igniter plate and drawn up and held on the outside by a hexagon nut. The insulation of the fixed electrode has been given very careful attention and requires no cleaning for thousands of miles if ordinary attention is given to the adjustment of the lubrication."

ANOTHER VIEW OF IGNITION.

In order that the reader may grasp more thoroughly the prinples that underlie all systems of ignition another view of the subject is given below.

Ignition is one of the most interesting parts of the general subject of gasolene motor mechanism.

If you know nothing of electricity, never mind. No one knows for certain what it is, but it is fairly easy to learn enough of what it does for the present purpose. Although magneto ignition is now the more prominent, it will be convenient to deal with the battery and coil system first.

The object of either apparatus is to obtain a spark in the combustion chamber, and this spark is made to occur between two points set a little distance apart. The space between the two points forms a breach in the electric circuit, and the electricity in jumping the breach causes the desired flame or spark.

Elementary Electricity.

One analogy is extremely useful to remember—electricity and wiring are very like water and piping. Suppose we have a tank of water and a large pipe having both ends connected to the tank. Means are provided for causing the water to circulate slowly through the tank and pipe, as by introducing a pump into the system. We next make a breach in the pipe. What happens? The water simply dribbles down from the breach, and we are done. We must get enough pressure on the water to make it jump across the gap. Instead of increasing the power of the pump, we will introduce into each of the broken ends of the large pipe a length of small pipe, and direct the free ends of these at each other, leaving a short gap between them as before. The pump insists on the water getting round the system in a certain time, and so it has to pass through the first length of small pipe at very high speed. There is only a small quantity of water in the small pipe, but it is under great pressure. Consequently it squirts out of the end of this small pipe and right across the gap into the end of the other one. By working the pump intermittently we can get intermittent squirts.

The interpretation is as follows: The tank of water corresponds to a collection or battery of cells, from which electricity will flow. The large pipe is the (primary) wire or other conductor through which the electricity flows in full volume, but at a low pressure. The pump, in combination with the small pipes, suggests (rather imperfectly) the induction coil, by which the (primary or low-tension) current of large volume and low pressure provokes in the secondary or high-tension winding a current of small volume and high pressure. The small pipes also correspond to the high-tension wire, and the gap between them is the gap between the points of the sparking plug which is screwed into the combustion space of the motor. The intermittent working is effected by a contact breaker, a device which is introduced into the primary circuit, and allows the electricity to flow for only short periods at regular intervals, as required for the sparking to take place in turn with the other operations of the motor.

The wire is more like the hole in the pipe than like the pipe itself, so the wires that have to carry the electricity away from the battery to the coil, and away from the coil to the sparking plug, must be provided with a covering or insulation to keep the current to its course. Like a schoolboy, the current displays a wonderful avidity for getting home, so the insulation of the return wires is of little, if any, importance;

and, indeed, in practice, the latter wires are largely dispensed with, the metal work of the car being used for most of the return conductor. As to the outgoing wires or "leads," if the insulation is defective in the neighborhood of conducting material, we must expect to lose our electricity—it will "short circuit," that is, take a short cut for home, without doing its work; just as we lose water from a leaky pipe, only more so. A somewhat similar point is that, though electricity, like water, will take the path of least resistance, yet where there are other outlets, some of the current may be expected to flow through them—the whole river does not run out through the main channel of the delta.

Electricity is rather more like gas than water in one quality. Water may be regarded as incompressible, but electricity appears to have a certain amount of elasticity; if it meets with an obstruction to its flow, it will gather or compress, and then, if the obstruction be not too great, will spring past it.

The quantity or volume of electric current is calculated in amperes, and is measured by an instrument called an amperemeter or ammeter. The pressure of the current is reckoned in volts, by a voltmeter. The product of amperes and volts is called watts. For example, 10 amperes × 5 volts =50 watts, or ½ ampere × 10,000 volts =5,000 watts.

The Batteries.

The battery may be either of the primary or of the secondary order. But the words "primary" and "secondary" do not here refer to the degree of pressure in the current, so much as to the manner in which the electricity arrives in them. A primary battery usually consists of three or four separate cells, each comprising a zinc element and a carbon element. The zinc is commonly employed to form the casing of the cell itself, while the carbon is in the shape of a bar. The bar is packed round with a depolarizer of oxid of manganese and bits of carbon. The space between the wrapping of depolarizer and the inside of the zinc casing is filled in with a damp paste compounded of plaster of paris and sal ammoniac. The top of the cell is sealed (except for a vent hole) with pitch, marine glue, or the like. The carbon is the positive pole of the battery, and the zinc is the negative; each is provided with a screw-threaded pillar or other "terminal," and the positive terminal in one cell is coupled up to the negative in the next cell by metal wires or strips. This is called wiring or coupling "in series," and it gives a comparatively high voltage with a comparatively low expenditure of current. If all the positive (carbon) terminals were connected together, and all the negative (zinc) terminals were connected together, the cells would be said to be coupled "in parallel," and the battery would give a great volume of current at a low voltage or pressure. See Battery.

When the cells are coupled up in series the carbon terminal of the one end cell and the zinc terminal of the other end cell become the positive and negative terminals of the whole battery. If the zincs of the cells form the exteriors thereof, it is necessary to insulate the cells from each other, and this is often accomplished by enveloping each cell in a rubber wrapping, holes being made for the passage of the coupling wires. The cells should be packed firmly in a box, as vibration would rub the insulation through and spoil the battery. The chemical action of the constituents of the cells is converted into electricity of low pressure—only about 1.25 to 1.5 volts per cell; and as over four volts are required, it is necessary to employ three or four cells. Primary batteries are clean to use, and give little trouble, but they cannot be recharged again and again like secondary batteries.

The Accumulator or Storage Battery.

Primary batteries are often called dry batteries, as there is little, if any, free liquid in them; and also to distinguish them from secondary batteries, in which the electrolyte is generally all liquid, though occasionally it is prepared in the state of a jelly.

The secondary battery or accumulator (commonly called a storage battery in automobiling), generally consists of two cells only, as secondary cells have a higher individual voltage than primary have. The (secondary) cells are generally put up in a single casing, constructed of sheet celluloid, with a central partition. It is essential that this partition be perfectly sealed. In each cell is a series of plates, positive and negative alternately, one more negative plate than positive, and as a rule there are three or five plates in each cell, both the outside ones being negatives.

The plates are made of lead alloy in skeleton or grid form of different patterns, according to the ideas of the manufacturer. The spaces in the plates are pasted in with oxid of lead. When the cells are charged, the paste in the positive plates becomes converted into peroxid of lead, while that in the negative plates becomes pure spongy lead. The cells are filled up above the tops of the plates with an electrolyte, usually consisting of a solution of sulphuric acid. The proper specific gravity of the solution is 1.190 or 1.200, and in preparing it distilled water or rain water should be used—not city, spring, or well water. Further, the acid should be poured slowly into the water, the converse process being dangerous. If the electrolyte is found not to cover the tops of the plates, the loss is probably due to evaporation, and a little distilled water should be added until the plates are submerged to the extent of one-eighth to a quarter of an inch. If the quantity of electrolyte has been reduced by spilling, it should be made up by adding some of the proper solution. Jelly electrolyte has the advantage that it cannot spill, but it is liable to increase the internal resistance of the battery and decrease the capacity.

A secondary or storage battery has no inherent electricity in it, as a primary or dry battery has; it requires to be charged either from other batteries, or from a dynamo, as described elsewhere. See under Battery, etc.

The Conductors.

Having obtained our supply of electricity, we will prepare to make use of it, remembering that the battery is ever on the watch for a chance to short circuit, and that this form of negligence is very bad for its internal economy, besides being wasteful of current. In choosing the wire for the primary or low-tension current, we must remember that it has to carry a fair volume of electricity, and it must therefore be comparatively thick; it will also have to be bent about a good deal, and will be subject to plenty of vibration, so it should be as flexible as possible. A cable constructed of a large number of fine wires will therefore be better for the purpose than one consisting of only three or four thick wires. It should be of ample length, as it is much more liable to break away from the terminals or connections if stretched tightly between them; any slack can be wound round, say, a cedar pencil, to form it into a spiral. As the current to be conveyed is of small pressure, the insulation, while perfect in itself, need not be very thick. But for the same reason, the connections or joints between the terminals of the battery and the terminals of the wire should be of ample surface and perfectly clean. There are lots of different patterns of terminals on the market, and it is better to use these, though fairly good terminals can be made with the ends of the wire itself. The ends of the wire have to be stripped of the insulation in either case, and if it is decided to solder the wire terminal, use resin for the flux, as the acid generally employed is corrosive.

One end of the wire is secured to the positive terminal (generally colored red) of the battery; the other end is secured to the terminal marked P ("pile"=battery) of the induction coil if of French manufacture, or B (battery) if an American or English one. The different systems of wiring are dealt with later on.

The Induction Coil

The name induction coil is indicative of the principle on which this apparatus acts. If two wires or other conductors are arranged parallel to one another, and an electric current is passed through one of them, it is found that a current also passes through the other one at the same time if the circuit of the second conductor is completed. There is no analogy to water here, and no explanation, intelligible to nontechnical minds, has been offered of the phenomenon, so far as we know. The wire through which the current is passed positively is called the primary, and the wire in which the current is induced is called the secondary. It has further been found that, if the primary and secondary wires are different in diameter and length and in number of turns, the induced current will differ in volume and pressure from the primary current.

This useful fact is availed of in coils for motor ignition to secure a current of great pressure or intensity and small volume, from a primary current of low pressure and greater volume, as given off by the battery. For this purpose the primary wire in the coil is made thick and short, while the secondary is thin and long. But the form of the spark bears some proportion to the secondary wire, and as we want a "fat" spark, the secondary wire must not be too attenuated in proportion to the primary. Fortunately, the wires need not be straight; the effect is obtainable even if they be wound into spirals. The effect is considerably augmented if a bar, or, better still, a bundle of wires, of soft iron be introduced as a core to the whole arrangement. Lastly, it is necessary that the different wires, and even the different plies or layers of wire, be insulated from each other.

Hence the coil for motor ignition takes a form as follows: Right in the middle we have a bundle of soft iron wires, Around these is wound a couple of layers of insulated thick primary wire, the ends being connected within the casing to the terminals. The primary wire or coil is then inclosed in a substantial insulator, such as a tube of vulcanite. Next comes a fine high-tension wire. This is not only covered with insulation, but each layer is insulated from the next, though the wire itself is continuous. The ends of the secondary coil are attached to the terminals within the casing; and the coil as a whole receives a liberal coating of paraffin wax insulation. There is also a condenser, which will be referred to presently.

At the moments when the battery current passes and ceases to pass through the primary coil, high-tension currents are induced in the secondary coil. But before the current can pass from the battery, the primary circuit must be completed, and we will therefore pursue its course from the coil. The wire from the battery being connected to the proper terminal, the next wire is connected to the other end of the primary coil by the other terminal. The remarks made with reference to the battery and coil wire apply to this one also; it may be called the "coil and contact breaker" wire. See illustration further on.

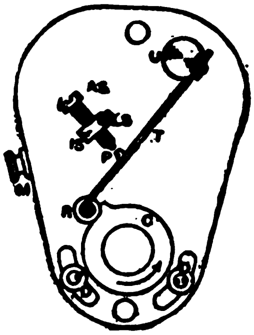
The Contact Breaker.

As the spark in each cylinder is required regularly once in two revolutions of the crankshaft, the current is caused to flow just at these times. The device employed for completing the circuit during the necessary periods, one might well expect to be called a "contact maker," and its full title is doubtless "contact maker and breaker;" but as its function of breaking the circuit happens to be even more important than that of making it, its common name is "contact breaker." It is sometimes called a "commutator," but that application is best reserved for another electrical fitting to be mentioned hereafter. The contact breaker is also adapted to provide means for timing the sparking, that is, causing the flash to occur a little earlier or later in the motor's cycle of operations. But the ordinary actuation of the contact breaker is effected by a rotating part mounted on, or driven by, the half-speed gear of the engine, the same gear as is used for working the exhaust valve.

Supposing for the moment that the contact breaker is in the "make" position, the primary current passes through it, and the primary circuit is completed by a conductor connected to the other terminal of the battery. This conductor may consist entirely of a wire, or it may be partly "earth" or "ground" and partly wire. See paragraph on "Connecting to Earth or Ground" later in this article.

The Make-and-Break Contact Breaker.

There are two principal types of contact breaker, known respectively as the make-and-break, or positive type, and the wipe. In the former, the rotating part consists of a disk C having a projection on it. The wire from the coil is connected to the terminal M which is in metallic contact with the pillar I S. This pillar carries two screws A S and L S the latter serving to prevent A S from turning after it has been adjusted to any desired position. A cover is fitted to the working parts to exclude dust and wet. This cover is provided with holes for the passage of two screws. Nuts screwed on to the screws hold the cover in position.



Make-and Break Contact Breaker, Positive Type.

The pear-shaped base into which the terminal M, the pillar I S, and the screws are fixed, is made of vulcanite or other insulating material. A spring blade or trembler T is fixed to the pillar U by a screw. On the free end of T is a block or roller R which rubs on the periphery of the disk C. When the projection comes round the blade is lifted by it, and makes contact with the point of the screw A S. This contact completes the primary circuit; the current enters by M, and passes through I S to A S, and from A S it passes to T and C, which are the beginning of "ground." But the contact is of very short duration, as directly the projection on the cam C has passed under the roller or block R the blade T springs away from the point of the screw A S. As soon as T and A S separate the current is cut off, and it remains cut off until in the course of the cam's rotation, the projection lifts the blade into contact with the screw again. Completing the contact has very much the same effect as turning on water from a faucet, and the trembler spark appears.

Function of the Condenser.

The condenser acts as a buffer or compensating device. It is constructed of a number of sheets of tinfoil, insulated from one another by sheets of paraffined paper. Half the sheets of tinfoil are connected to one wire, and the alternate ones are connected to another. The other ends of the wires are connected indirectly to the screw A S and blade T (or corresponding parts) of the contact breaker. When the primary current strives to continue flowing after the contact is broken, a good deal of it passes into the condenser. And when the contact is again made, the electricity stored in the condenser helps to re-establish the flow quickly. That is not a wholly satisfactory explanation, but it is as far as one can take the matter in an elementary way. These flowing and compressing and bursting actions of the current are performed with extraordinary rapidity.

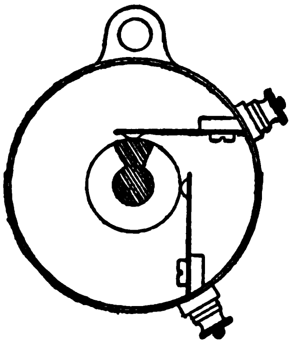
Advancing and Retarding the Ignition.

In order to be able to vary the moment of sparking relatively to the operations of the motor, the insulating baseplate can be turned about the axis of the disk. The turning movement is limited by the studs D D (carrying split pins) projecting through the curved slots. The driver effects the movement through a rod connected to the baseplate. The disk C generally rotates contra clockwise, so that if the baseplate is turned to the right or clockwise, the projection will meet the block sooner, and the ignition will be advanced. If the baseplate be moved in the opposite direction the projection will meet the block later, and the ignition will be retarded. The speed of the engine is, under ordinary circumstances, increased or decreased, according as the ignition is advanced or retarded. The movement of the baseplate does not alter the relative positions of any of the parts mounted upon it, it only alters the position of all of these relatively to the disk C.

Wipe Contact Breakers.

There are several kinds of wipe contact breaker, but they nearly all differ essentially from the make-and-break in that the rotating part has neither notches nor projections. See Contact Breaker and Contact Maker.

In the two-cylinder wipe contact breaker shown in the illustration, it will be observed that there is a sector of metal let into the disk, which in this type of contact breaker is constructed of vulcanized fiber or other insulating material.



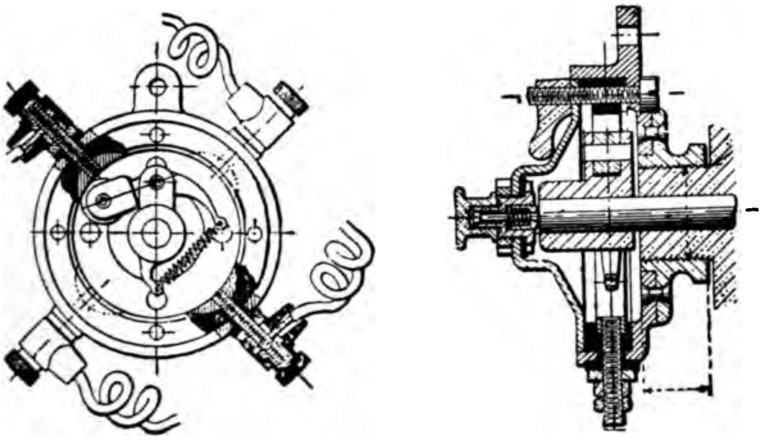
Two-Cylinder Wipe Contact Breaker.

The metal sector is in permanent metallic contact with the half-speed shaft, and so with the motor, which is, in turn, connected, generally through part of the car frame, with a short wire leading back to the battery. Bearing on the periphery of the disk are two blocks, carried by spring blades, which are mounted on insulated supports connected with the terminals. There are two blades, because the particular contact breaker illustrated is intended for a two-cylinder motor; they are arranged in positions corresponding to the intervals at which the respective impulses are adapted to take place—either at intervals of 1 and 3, as shown, or of 2 and 2, as the case may be. The rocking of the baseplate for timing the ignition affects both blades alike, but each blade is "wired" independently to the coil or coils. Sometimes a separate coil is used for each cylinder, but now it is very usual to employ a single coil in conjunction with a distributing device for the high-tension current. The latter is probably the better arrangement, as tending to evenness of action in the various cylinders. We will describe it more fully in connection with the high-tension circuit.

As the metal sector comes under each blade or "brush" (a dynamo term), the primary current passes through it. Owing to the large arc of the sector, the current flows for a comparatively long time. But as the half-speed shaft turns in the oiled bearings, and oil separates the teeth of the half-speed gear wheels and also the crankshaft from its bearings in the fixed part of the motor, the current has not by any means an ideal path back to the battery; and a wipe contact breaker may often be considerably improved by fitting, first, a spring to bear on a metallic part of the disk or on the end of the half-speed shaft; and second, a wire leading direct from this spring back to the battery.

The Internal Wipe Contact Breaker.

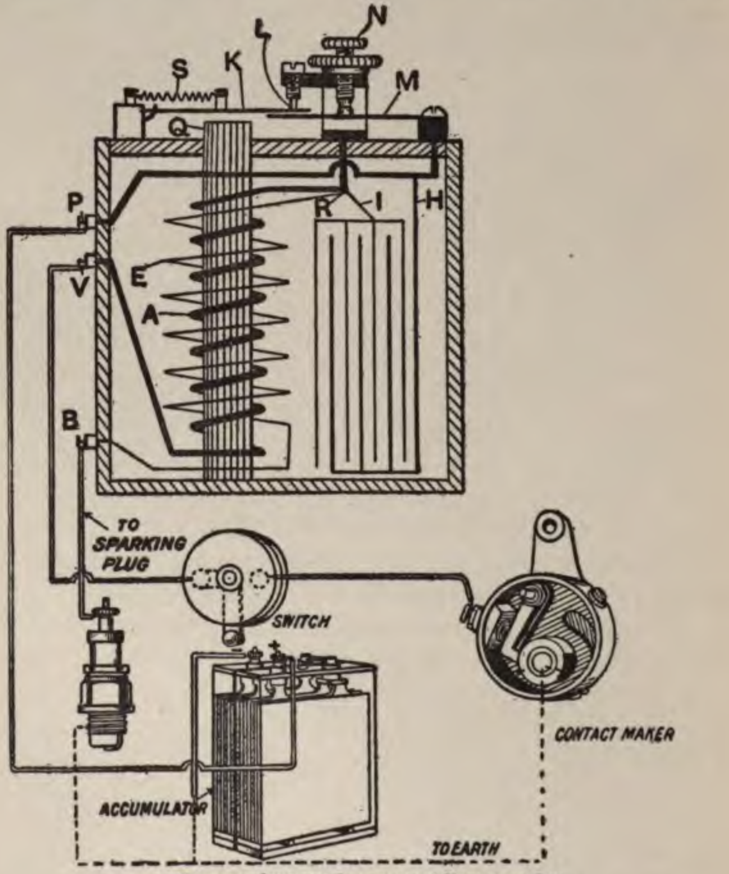
The illustrations in this paragraph represent another pattern of wipe contact breaker. This one is intended for a four-cylinder motor, but it may be modified to suit motors having any other number of cylinders. The construction is the converse of the last. In this case there is only one brush, and it is mounted on, and rotates with, the half-speed shaft, while metal segments, corresponding in number to the cylinders, are carried by the case, which may be moved about its center to regulate the time of firing. The brush is pivoted to an arm fixed to the half-speed shaft, and is furnished with a roller, which runs round the vulcanized fiber lining (with metallic insertions) in the case. A spring couples the other end of the brush to a second arm on the half-speed shaft, and forces the roller into close contact with its path. The metal segments are in one with terminals projecting through the rim of the case, and each terminal has its own low-tension wire connection. The primary circuits are completed in turn as the brush runs over each metal segment; but here again there are a number of films of oil to be overcome before "ground" is properly reached, and the spring contact pressing on the end of the half-speed shaft forms a useful addition.



Four-Cylinder Internal Wipe Contact Breaker.

Trembler Coil Theory.

With a trembler coil an extremely rapid make-and-break device is employed on the coil itself, and is adapted to operate while the wipe contact breaker is in the make position, i. e., while the brush is moving over the metal segment, or vice versa, as the case may be. With a make-and-break contact breaker, the trembler on the coil would vibrate during the time the platinum points of the screw and blade remained in contact. The trembler movements are constructed in different ways, each maker striving to get the fastest action, but the principle is the same in all. A light metal blade K, resilient either in itself or by reason of a separate spring, S, is held by one end on the coil, and frequently carries an iron plate or armature in line with the core of soft iron wire. This blade, or one (M) which it overlaps, carries a platinum point opposite the platinum-pointed end of an adjustable screw N.



ELECTRIC IGNITION SYSTEM WITH TREMBLER COIL.

A, Primary wire coil.
B, Secondary wire terminal.
B. Secondary wire coil
H I. Condenser leads from blade M and screw N
K. Armature blade.
L, Adjustable stop.
M, Trembler blade with platinum point
N. Platinum pointed screw.
P, Battery terminal of primary wire.
Q Soft iron wire core. (winding and condenser
R Common connection of primary and secondary
S, Trembler blade spring.
V, Contact breaker terminal of primary wire.

The device, as a whole, is introduced into the primary circuit, the wires being indirectly connected to the parts carrying the two platinum points.

Normally the platinum points are held in contact by the pressure of the spring, so the path is complete, ready for the passage of the current. Hence, when the circuit is "made" by the contact breaker, the current is admitted to the primary winding A of the coil. The current has the effect of "exciting" the soft iron core Q, that is, causes it to act as a magnet which promptly attracts the plate or armature, bending down the blade which carries it. But the necessary consequence of bending down the blade is to separate the platinum points, and so break the circuit. On the current ceasing, the core loses its magnetism and releases the armature, with the result that the blade springs up again and re-establishes the contact between the platinums. This remakes the circuit, the core is remagnetized, the plate attracted, and contact again broken. And so on, again and again, at speeds that almost defy calculation.

Of course, the block and segment of the contact breaker do not continue in contact for more than a small fraction of a second on each occasion, but this is long enough for numerous inductions of high-tension current, and the flashing of a stream of sparks, the individuals of which follow each other far too quickly to be distinguished by the human eye. This kind of coil has two incidental advantages arising from the buzzing sound set up by the vibration of the trembler. First, the emission of the sound is evidence of the satisfactory condition of the ignition system to a large extent; and second, it serves as a warning to switch off the current before leaving the car, if it happens to stop while the contact breaker is "on the make."

The High Tension Circuit.

So much for the primary or low-tension circuit. The secondary or high-tension circuit now remains to be disposed of. We have seen how the high-tension current is induced in the fine secondary winding of the coil. The induction coil really comprises two coils—the primary and the secondary; and each of these is often referred to as a winding, primary or secondary, or high or low-tension respectively, as the case may be. One point may be noticed at once— while the primary circuit is sometimes furnished with a complete return wire, the secondary circuit is practically always arranged with an "earth" or ground return. There are good reasons for this. In the first place the sparking plug can be made quite a simple affair if the return is by ground. Secondly, as the plug is tightly secured in a stationary part of the motor, the "earth" affords a comparatively good path for the current. And thirdly, the powerful nature of the high-tension current enables it to overcome any little obstacles to its flow that it may encounter. But while the high pressure of the secondary current is a good reason for grounding the return, it is an equally good reason for very carefully insulating the wire conducting the current from the coil to the sparking plug.

As compared with the low-tension wire for the primary circuit, the high-tension wire should have a very much thicker envelope of insulation, and even then the wire should be kept away from metal parts as much as possible. The coil should be arranged as near as may be to the sparking plugs, so that the length of high-tension wire may be reduced to a minimum. The actual wire should be of fine strands, to insure durability, but there need not be as many strands in this wire as in the low-tension, as the volume of current flowing through it is so much less. The high-tension wire is attached to the terminal B ("bougie," literally candle) on a French coil, or S P (sparking plug) on an American or English one. The return circuit often enters the coil by the same terminal as the low-tension return, the one terminal serving for both. The high-tension wire should be only a little longer than necessary; partly because the thick insulation makes it too stiff for any excess to be wound into neat spirals, and partly because the longer it is the more chance there is of its finding opportunities to leak.

High Tension Distributers.

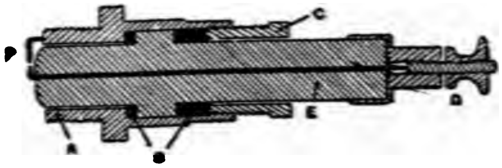
If the engine has only one cylinder, there will be only one high-tension wire; but if there are two or more cylinders, there will be a wire for each, and there may be a coil for each. In the latter case there will be independent primary wires from the contact breaker to the respective coils, and independent high-tension wires from the respective coils to the corresponding sparking plugs. But, as stated, it is common practice nowadays to employ a single coil for all the cylinders, and to direct the high-tension current to each plug in turn. For this purpose a distributer is employed. In appearance, and to a certain extent in action, the distributer resembles a contact breaker. A single high-tension wire leads from the coil to a terminal which is in metallic contact with a rotating arm. As the arm rotates it communicates the current, in turn, to each of a number of metal blocks, which are connected up to the respective sparking plugs by separate lengths of high-tension wire. The arm is rotated by the motor, and, of course, at such a rate that the high tension current is transmitted to each plug at the correct period in the cycle of operations.

The high-tension wires should be carried in a vulcanite or fiber tube extending along the top of the motor. Opposite each cylinder a hole is made in the tube, and the proper wire led therethrough to its plug. This arrangement prevents both entanglement of the wires and loss of current.

The Sparking Plug.

The sparking plug is designed with the object of providing within the combustion chamber of the motor, a gap in the secondary or high-tension electrical circuit, so that the current, in jumping the gap, may cause a spark or flame that will ignite the charge of gas and impart an impulse to the piston and rotation to the crank shaft. The gap, which should measure about one-thirty-second of an inch, is provided between two points, which are best made of platinum to stand the heat. One point is formed on one end of an insulated pin or thin rod. The other point is formed on a short wire secured to the metal body A of the plug. The body is screwed into the wall of the combustion chamber of the motor, and the second point is thus "grounded" to the secondary winding of the induction coil, one end of this winding being itself grounded, as already mentioned. Sometimes disks or blocks of various shapes are employed instead of wire points, and plugs thus constructed may spark at more than one place.

Porcelain is the material generally employed for insulating the pin in the plug, though mica and other materials are sometimes used. The pin is secured in the center of the insulation E, and projects from it at each end. The outer projecting end is fixed to a terminal D for connecting up the high-tension wire, and it is a convenience, especially in a motor having several cylinders, if the connection can be made and unmade instantaneously. The body of the plug is provided with an external screw-thread and with flats, whereby it may be screwed into the head of the motor. It is also screw-threaded internally to receive a hollow screw C. The insulation E is formed with a collar or swelling, which rests on a shoulder in the lower part of the body, and the hollow screw is screwed down on the top of it so as to hold it in place. Asbestos packing B is introduced above and below the collar to insure a gas-tight joint, and to prevent the pressure of the metal parts crushing the porcelain. A washer of asbestos and copper should be used in securing the plug in the motor, to insure close-fitting and prevent leakage of compression.



Section of Sparking Plug.

A, metal body with screw thread. B, packing. C, hollow screw. D, terminal for high-tension wire. E, insulation. P, points.

Many plugs are made with the ends of both wires bent to form the gap, but as the porcelain will sometimes slip round a little when the terminal is being tightened up, it is better for the central wire to be left straight, and only the short one bent; then the turning of the central wire will not disturb the width of the gap so much. Of course, if the gap is too wide, the current will not jump it, and there will be no spark and no impulse. Plugs vary greatly in price, and individual cheap ones will sometimes give better results than others at five times the price. Some are specially constructed to allow for easy refitting of the porcelains in case of fracture; and in the case of the best, and therefore somewhat expensive plugs, this is an advantage.

The External Spark Gap or Intensifier.

This completes the apparatus for inducing the electric current to jump the gap in the cylinder, and fire the charge in doing so. Sometimes, however, through mismanagement of the mixture or the lubrication, or both, the inner end of the sparking plug becomes fouled with carbon; and this being a conductor of electricity, the current will prefer taking a course through the carbon deposit to jumping the gap; or, if the battery is running low, and the points of the plug are too far apart, the current may refuse the leap. Under these circumstances an external spark gap or "intensifier" is found useful. It is frequently provided at the sparking plug terminal, and consists of two metal points mounted on insulating material, and adjusted to about a millimeter (1-25.4 in.) apart; or, if a distributer is used, the rotating arm may be made just too short to reach the metal blocks. The effect is the same in either case. The current is momentarily obstructed by the outside gap, but when it bursts across it the impetus enables it to jump the inside gap also—"outside" and "inside" having reference to the cylinder. The passage of the outside gap is accompanied by a spark, so the device is useful as a visible indication of the state of the ignition. As cases have occurred of the outside spark firing stray gas, it is better to use a pattern in which the gap is inclosed in a glass tube.

Wiring.

The wiring or system of coupling up the various terminals, in the ignition system is of vital importance, as, unless correctly done, no effective sparking will result, and serious damage may be done to the apparatus. Every car should be accompanied by a book of directions containing an easily-understood diagram of the wiring. But this should be backed up by the driver's own knowledge of the subject, and the following hints and illustrations will enable him to deal with most of the cases he is likely to come across.

As to the battery—the positive pole is generally colored red, or it may be marked with a plus or "positive" sign +; it forms the terminal of the positive plates, which are of a chocolate color when the battery is charged. The reddish color plates have the red colored terminal. This positive terminal is generally coupled to the coil.

The negative pole of the battery is generally colored black, or it may be marked with a minus or "negative" sign —; it forms the terminal of the negative plates, which are of a grayish color, and two of which form the outside plates of each cell. This negative terminal is generally wired to the contact breaker, either directly or via "ground."

The Electric Switch.

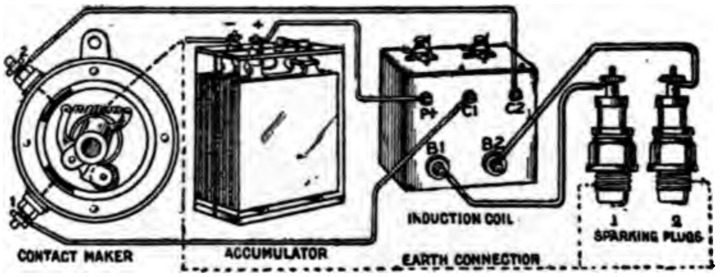
An electric switch is familiar to everyone in these days. It comprises a spring-controlled handle, the movements of which open and close a gap between two metal fittings introduced into the circuit, so that the current is cut off or allowed to flow, as required. Some switches are made with a handle that can be detached when leaving the car, thus protecting it to a certain extent against meddlers.

Many motor switches are made with two "on" positions and one "off." These are fitted when the ignition system includes—as it should—two batteries. Batteries being still somewhat erratic in their behavior, it is very desirable to have one in reserve; and it is a further convenience to have this wired up in such a way that the movement of the switch from one "on" position to the other will enable it to be brought into action should the other battery for any cause cease firing. The two accumulators should be coupled "in parallel" that is, the two positive terminals should be coupled together, and the two negative terminals should be coupled together. The two-way switch should be introduced into one (either) of these couplings, and the switch and the remaining coupling should be connected by single wires to the coil and to the contact breaker (or to ground) or vice versa, as the case may be. Then, though both accumulators will be directly connected either to the coil or to the contact breaker the primary circuit will only be completed through one accumulator at a time, according to which side the switch handle is moved over to. When the handle is in the middle position the switch will cut out both accumulators. Instead of a coupling and single wire, it is often more convenient to run two separate wires from the two like terminals of the accumulators to the single corresponding terminal of the coil or contact breaker (or ground). Or one may run one wire from this single terminal (or ground) to the terminal of one accumulator and a short wire thence to the similar terminal of the other accumulator. The switch wiring must remain as before.

Connecting to "Earth" or "Ground."

As there are two windings (primary and secondary) in the coil, one may naturally expect to find four terminals on the casing, one for each end of each winding. And sometimes this is the case: the two primary terminals being for connection to the battery and contact breaker respectively, and the two secondary terminals being for the sparking plug wire and "earth" return respectively. More often, however, if a coil has four terminals, the fourth is intended to be connected to earth instead of to the contact breaker, which is then made with only the one terminal. It is now usual to provide the coil with only three external terminals, the ground end of the secondary winding being connected, inside the casing, to the contact breaker terminal of the primary winding.

With this construction, at the moment of making contact, both the primary and secondary currents pass through the coil-contact-breaker wire, the primary current being grounded only between the battery and the contact breaker on the motor. The same idea is carried out further where two or more coils are boxed up together in the ignition system of a motor having two or more cylinders. Here, one end of each primary winding is taken to the inner end of a single terminal P+, the exposed end of which is coupled up to the battery; the other ends of the primary winding being provided with separate terminals, which are wired to the corresponding terminals of the contact breaker (contact maker). And the earth ends of the secondary windings may also be taken to a single terminal, while the other ends are connected to separate terminals for the respective sparking plugs.



System of Wiring with Five-terminal, Double Coil, Wipe Contact Breaker, Earth Returns, and Two Sparking Plugs.

Identifying Connections.

In the ignition systems of motors having two or more cylinders, the sparking plug boss, the contact breaker arm or block (that is, the duplicated, non-rotating element of the contact breaker), the contact breaker terminal on the coil, and the trembler blade, in each set should be marked with a corresponding number. If it has not been done by the maker, you will be wise to do it at your leisure as soon as possible, as it may save a lot of hunting about and mistaken diagnosis on the road. It is also a convenience to use wiring differing in appearance, by color or otherwise, for the different sections, so that each wire can be identified at different points in its length with certainty and dispatch.

MAGNETO IGNITION.

The great objection to the use of batteries, whether wet or dry, is that the supply of electricity is not permanent—the former kind requires recharging from time to time, the latter has not even a renewable existence. One looks, therefore, for a source of electricity that will be replenished "while you go on" instead of "while you wait." And it is found in the magneto system, by which a dynamo driven by the engine generates electricity at a very small expenditure of power. See Magneto Ignition.

The dynamo consists essentially of a number of steel magnets of inverted U or "horseshoe" shape, arranged so as to form a tunnel or long arch, and an armature wound with insulated copper wire and disposed along the arch so as to lie between the ends or poles of the several magnets. The magnets are excited in the first place by a powerful dynamo, and, as they retain their magnetism for a very long time (sometimes for a number of years), they are called permanent magnets. This term distinguishes them from electromagnets, which are made (as in the case of the core of a trembler coil) of soft iron, and are only excited so long as a current of electricity is passing through wiring coiled round them.

The flat horseshoe magnets sold largely as toys are permanent magnets, and "lines of force" pass across from one pole, called the north or positive, to the other, which is called the south or negative. If a conductor of magnetism (such as iron, but not brass or copper) be introduced between the poles, the lines will tend to deflect and pass straight through the conductor. The armature, being of soft iron, induces the lines of force to pass through it in this way.

The Armature Winding.

Now it was discovered by Faraday that if a circuit of copper wire be caused to cut these lines of magnetic force, an electric current would be set up in the wire. The current flows in one direction when the wire passes across the lines, say, upward; and it flows in the opposite direction when the wire crosses the lines the other way. This is called an alternating current. In practice, the armature is provided with two, deep, longitudinal grooves, one diametrically opposite the other, so that the transverse section looks something like the letter H. Insulated copper wire is wound on to the armature lengthwise so as to lie in the grooves. The wire used is short and thick or long and thin, according as a low-tension or a high-tension current is required. A spindle is mounted on a brass plate or bridge at each end of the armature, and bearings are provided for the spindles, so that the armature may be rotated by the engine. The armature, with its winding, takes the form of a solid cylinder, and the magnets are fitted with concave pole pieces, almost in contact with which the armature rotates.

Generation of the Current.

When the crossbar of the "core" of the armature lies transversely between the pole pieces, the lines of force run directly through it; and even when the armature has been turned through such an angle that the bar points for the upper part of one pole piece and the lower part of the other, the bulk of the lines will prefer to take the distorted path through the core instead of running directly across from pole to pole through the air. But while the core is turning from this position to about the vertical, the copper wire will cut all the lines of force. The uppermost lines of force starting from the north pole will jump from the lower part of the south pole to the upper part thereof; and the lowermost lines of force entering the south pole will drop from the upper to the lower part of the north pole. As each jump and drop takes place, the lines of force are cut by the coils of the armature winding, and a current is set up therein. By the time the core has reached a vertical position the current will have attained its maximum, and the lines of force divided into two parts, one passing through the upper segment of the armature and the other through the lower. See illustrations near beginning of first article on Ignition.

Then, as the armature continues its turning movement, the cutting begins again, but the opposite way—both as to the lines and the coil, so that the current continues to flow in the same direction, but with decreasing intensity. When the core has become horizontal again the current has ceased, and on restarting it flows in the opposite direction. When the most lines of force are being cut, that is, about the times the core attains its vertical positions, the currents are at their highest or maximum, and it is at or about one of these two times that the current is generally utilized. When no lines of force are being cut, the voltage falls to zero.

The Armature Spindle.

One can, by suitable adaptations, draw off the electricity generated, either as an alternating or as a continuous current. For an alternating current one end of the armature winding is generally grounded to the body of the armature, and the other is passed axially through one end of the armature spindle which is made hollow for the purpose. This end of the wire is insulated from the spindle, and is either furnished with a metal terminal or is connected to a metallic ring; the terminal or the ring is suitably insulated from "ground." If a terminal is used, the current is received by a spring blade or brush bearing either directly against the end of it or through a carbon rod or other suitable conductor. In the case of a ring commutator, the same rotates co-axially with the armature, and a brush bears upon its periphery. The blade or brush is insulated, and the current is led through it to an insulated wire, which is connected up to the apparatus to be operated. A continuous current is not often used for magneto ignition.

Some motorists couple up a dynamo, driven by the engine, to their accumulator to insure keeping the latter fully charged. But few cars are so equipped as standard pattern; nor is a dynamo ever regularly fitted as a mere substitute for a battery, though such an arrangement might offer certain advantages.

The Bosch Arc Light Armature.

The arc light armature is remarkable, not only for the fact that it is stationary, but also for the method of winding. There are two coils of wire, one short and thick, the other long and thin, as in an induction coil. But instead of the two coils being kept strictly separate, one end of the fine wire is connected to one end of the coarse. The other end of the primary wire, as it may be called, is "grounded" to the core, and the other end of the secondary wire is led centrally down the hollow spindle of the armature. Within this hollow spindle the end of the secondary wire is connected to one arm of a ⊃ piece, the other arm of which carries a carbon brush, which leads the high-tension current to a metallic ring in the disk of the distributer. Notwithstanding that the two coils are directly connected, they have the desired transforming effect, and a current of great intensity is produced in the secondary winding. The return for the high-tension wire, it will be noticed, is right through the primary wire.

Contact Breaker and Distributer.

From the point where the two wires are connected together, an insulated tubular conductor extends through the hollow spindle of the armature, and is coupled up to the stationary portion of a contact breaker. The live end of the high-tension wire and part of one end of the ⊃ piece lie within, and are insulated from, the tubular conductor. To the end of this conductor is clipped an irregularly-shaped bar, which is connected at its other end to a block carrying the stationary part of a make-and-break contact breaker. The moving part of the contact breaker is earthed, and consists of a lever pivoted transversely in the lower end of the timing lever. The upper end of the contact lever carries a platinum tip in line with the similarly-tipped screw forming the stationary contact; the lower end of the contact lever bears upon a disk fixed to the rotating sleeve. In the face of the disk there are four equidistant recesses, leaving four intermediate projections. When a recess comes round opposite the lower end of the contact lever it allows the upper end thereof to move forward (under the action of a spring), and so complete the contact.

A condenser is packed in a casing arranged over the armature and sleeve. The terminals of the condenser are connected to the stationary part of the contact breaker and to earth respectively; so the condenser is practically connected across the points of the contact breaker, as usual.

The distributer disk is mounted upon, and rotates with, one of the sleeve spindles. A brass ring is let into the disk and a segment in connection with the ring extends to the periphery. Four insulated carbon brushes, with suitable terminals, are mounted radially and equidistantly in a casing surrounding the disk, and the high-tension current transmitted to the ring by the brush in the ⊃ piece is distributed to each of the four radial brushes in turn by the brass segment. The terminals of the radial brushes are coupled up to four vertical sockets by suitable leads. These sockets are sunk in the lower part of a vertical insulator plate; the top half of the plate carries four corresponding pins, the lower ends of which fit snugly into the sockets, while the upper ends form terminals for the respective sparking plug wires of a multi-cylinder motor. If the motor has only one or two cylinders, the surplus brushes will not be utilized, and only one or two sparking plug wires will be attached. The plate and its fittings provide a ready means for breaking the electrical connections when required. The sparking plugs may be of the ordinary kind, though the makers of the magneto recommend the use of one known by their name. No contact breaker is required on the camshaft, nor any coil, apart from that of the armature.

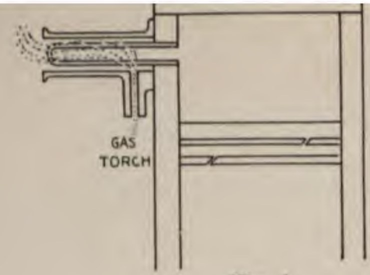
Action of the System.

The contact breaker lever and one end of the primary wire being earthed, and the other end of the primary being connected through the conducting tube and the bar with the stationary contact screw, the primary circuit is completed every time the platinum points make contact; and the current, then being generated, takes this course. But as the [illegible] passes away, the adjacent projection pushes [illegible] lever forward and the upper end back. [illegible] The break is timed to occur when [illegible] maxima, and while the segment [illegible] brushes. The contact [illegible] separated, the high-tension current is [illegible] secondary circuit, traveling through [illegible] conductor, the ⊃ piece, [illegible] ring and segment, one of [illegible] and plug appertaining to [illegible] table to the points of the [illegible] arm and the primary wire [illegible]

[illegible] the lower end of the con- [illegible] projections on the [illegible] and the moment of [illegible] axis of the timing [illegible] the movements of this [illegible] positions of the contacts. [illegible] device, a single spark [illegible] spark appears to be [illegible] charge, and will fire [illegible].

[illegible]

[illegible] gap at the [illegible] was otherwise [illegible] being dis- [illegible] and so spoil [illegible] against [illegible] spark gap is [illegible] render and [illegible] in emergency [illegible] for the [illegible] If it is desired [illegible] current generated as [illegible] circuit should be [illegible] wire, one end [illegible] conductor bar.



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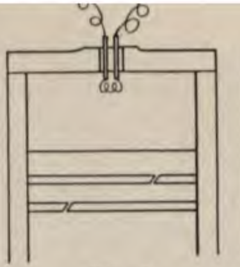


Fig. 2.

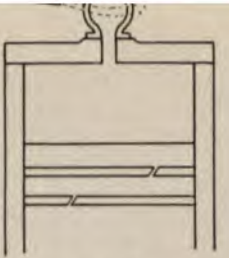


Fig. 3.

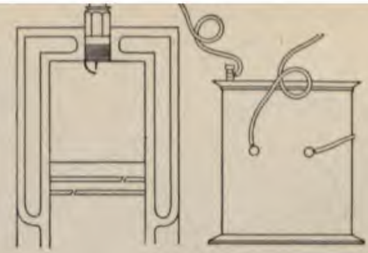


Fig. 4.

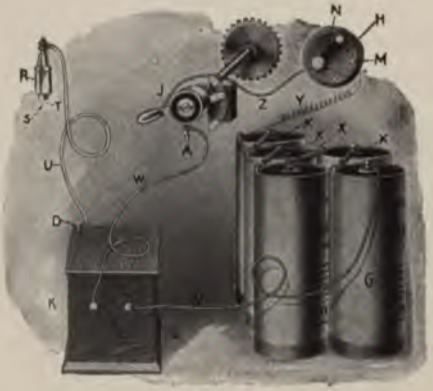


Fig. 5.

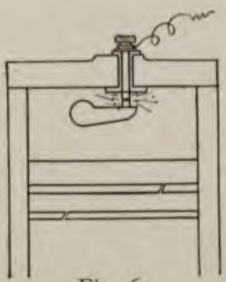


Fig. 6.

Various Methods of Ignition.

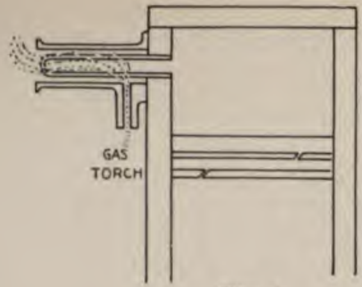
Fig. 1—Hot Tube; Fig. 2—Incandescent Wire; Fig. 3—Heated Surface; Fig. 4—Electric Spark; Fig. 5—High Tension or Jump Spark; Fig. 6—Low Tension or Make-and-Break Spark.

recess in the disk passes away, the adjacent projection pushes the lower end of the lever forward and the upper end back, thus breaking contact. The break is timed to occur when the current is at one of its maxima, and while the segment is in contact with one of the radial brushes. The contact breaker points being separated, the high-tension current is forced to traverse the secondary circuit, traveling through the secondary wire, the inner tubular conductor, the ⊃ piece, the lateral carbon brush, the brass ring and segment, one of the radial brushes, the lead, socket and plug appertaining to that brush, and the high-tension cable to the points of the sparking plug, and returning via "earth" and the primary wire to the secondary winding.

Rocking the timing lever causes the lower end of the contact lever to encounter the recesses and projections on the disk sooner or later, as the case may be, and the moment of sparking is changed accordingly. As the axis of the timing lever is in line with the platinum points, the movements of this lever do not displace the relative positions of the contacts. There being no trembler or equivalent device, a single spark only is produced at each plug, but this spark appears to be particularly well adapted to firing the charge, and will fire very weak mixtures.

An Emergency Exit.

If the high-tension current failed to jump the gap at the plug (it should measure exactly .4 mm.), or was otherwise interrupted, as by one of the sparking plug leads being disconnected it might "break down" the insulation, and so spoil the apparatus. To guard against this risk, a spark gap is arranged between the lateral or feeder brush holder and the conductor bar, thus providing an emergency exit for the current. But this is only a temporary relief. If it is desired to run the magneto without using the current generated (as in the case of dual ignition systems), the circuit should be shorted by means of a switch introduced into a wire, one end of which is connected to the terminal on the conductor bar,



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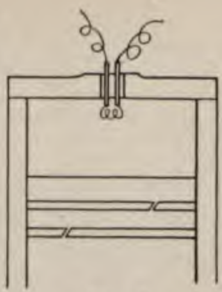

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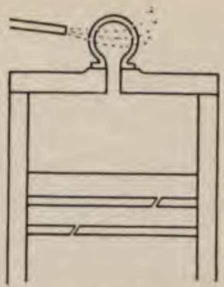

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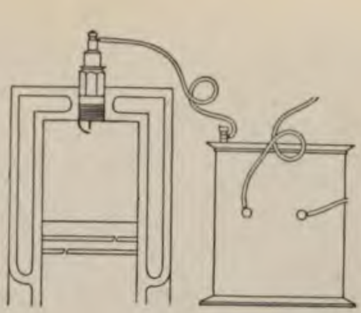

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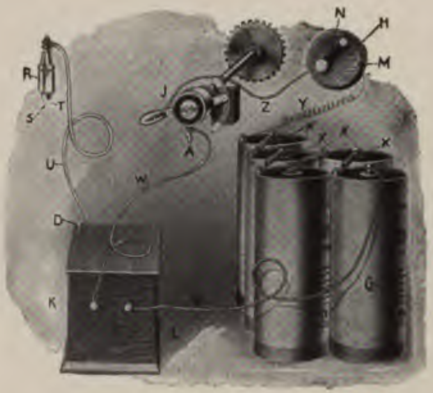

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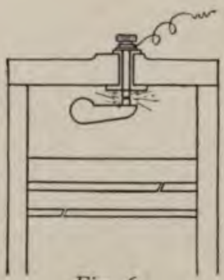


Fig. 6.

Various Methods of Ignition.

Fig. 1—Hot Tube; Fig. 2—Incandescent Wire; Fig. 3—Heated Surface; Fig. 4—Electric Spark; Fig. 5—High Tension or Jump Spark; Fig. 6—Low Tension or Make-and-Break Spark.

while the other end is grounded. By setting the switch so as to connect the parts of the wire, the primary circuit is short-circuited, and all risk of damage removed.

Dual Ignition.

As it is often easier to start up a car on battery and coil ignition than by a magneto, and as with the former system it is frequently possible to restart the car simply by switching on; and, further, with a view to immunity from total failures of the ignition, many users of magneto ignition prefer to employ an accumulator or battery and coil system as well. This means a certain amount of complication, and, in order to reduce it as far as may be, the two systems are often combined to a greater or less extent, and are then referred to as dual ignition. In this, the one set of plugs and the one distributer are used in common for both systems, and a switch is employed, which serves to couple up the battery and coil, while it cuts out the magneto, and vice versa. The.switch also serves to short-circuit the primary of the magneto, both when the battery is in use and when both systems are switched off. One might think that, where the magneto was of the low-tension kind, working with a coil, the one coil might be used for both systems, but this is seldom practicable, as the current generated in a magneto primary is generally considerably greater than that generated by a battery.

GENERAL SUMMARY OF IGNITION.

All so-called gasolene motor cars, that is, cars fitted with gas engines of one type or another, are now fitted with some form of electric apparatus to ignite the explosive mixture in the cylinder. No agent has proved itself so generally convenient, reliable and safe as electricity.

Other systems which have been or are being tried are:

(a) Ignition by a very hot tube (made hot by an external flame, generally from a gasolene lamp).

(b) Ignition by a very hot wire (made hot by catalytic action).

(c) Ignition by an injection of very hot jet of air or gas (made hot by compression in a small pump).

(a) Tube Ignition—This has been practically abandoned, chiefly on account of the danger of fire from the flame, the trouble with the lamp going out, and, lastly, the impossibility of advancing or retarding the moment of firing while the car was in motion.

(b) Catalytic Ignition—This has never passed the experimental stage. The heating of the ignition wire depends on the fact that when certain metals such as platinum and palladium are exposed in a spongy or finely divided state to the action of mixed explosive gases such as hydrogen or gaseous hydrocarbons and oxygen, they absorb these gases to a slight extent and in so doing become sufficiently hot to fire such a mixture of gases as occurs in the cylinder of a motor car. Catalytic plugs based on this principle have been used with but moderate success owing to the necessity for electric heating of the wire to start the car, to the necessity for supplemental electric gear to obtain the power of timing the ignition; and to the uncertainty of the action; for example, the heating effect does not take place if the plug should become coated with a layer of soot or lubricating oil.

(c) Hot Air Ignition—This is perhaps the most promising of the experimental systems. The idea worked out by some engineers is to compress very highly a small quantity of air or mixture in a separate pump, driven from the engine, until the air has attained a temperature sufficiently high to ignite the mixture. It is then injected into the cylinder, at this temperature, towards the end of the compression stroke. Timing is effected mechanically.

Electric Ignition Systems.

1. Electric ignition is always effected by passing a small electric current (rendered visible by its effect as a brilliant spark) through the mixture of gases it is desired to fire. Electric ignition devices may be classed in two groups, High Tension and Low Tension, and excellent results can be got from either system.

2. High tension is perhaps the more popular. Current is primarily obtained either from—

(a) Accumulators or so-called storage batteries (generally a battery of two cells).

(b) Dry cells (generally a battery of from four to six cells).

(c) A dynamo machine driven by the engine on the car.

(d) A magneto machine driven by the engine on the car.

The primary current, whether it be derived from a, b, c, or d, must—

(A) Be strictly limited to the primary circuit (that is, it does not go to the engine or spark plug at all).

(B) It must flow round a helical coil which is concealed in the coil box. (See Induction Coil.)

(C) It must be interrupted with great suddenness (or even reversed in some cases) while it is so flowing, by means of some interrupter arrangement usually fitted with platinum contacts.

(D) It must be of sufficient amount, say half an ampere, to thoroughly magnetize the coil.

(E) It must be supplied under a sufficient pressure (four or six volts) and for a sufficient length of time to insure (D) above.

3. The effect of these five things happening at the proper moment is as follows:

(i.) At each sudden interruption above alluded to a secondary current arises. (Notice that the mere steady flow of the primary current has no useful effect.) It must be interrupted in a sudden manner.

(ii.) This secondary current is kept quite distinct from the primary. It is also different from it in every characteristic, and flows round an entirely distinct and separate circuit.

(iii.) The origin or birthplace of the secondary current is in the coil box, not the battery. It is not even in the same helical coil of wire as the primary, but in a secondary coil placed near to it and around it, insulated from it with silk, wax, ebonite, etc.

(iv.) The amount of the secondary current is very minute, say a thousand times less than an ampere.

(v.) The pressure or voltage which forces it round the secondary circuit is, however, very high, say 20,000 volts. Hence the name, High Tension system.

(vi.) The high tension has a strong tendency to break down or pierce by means of a spark the weakest spot of any insulation on the wires of its circuit; for this reason a very thick rubber coat is put over this wire where it is exposed.

(vii.) The above fact is utilized and a weak spot in the insulation is purposely provided at the place where the points of the spark plug are nearest to one another, viz., inside the engine cylinder where the spark is wanted. See Spark Plug.

From the characteristics of the secondary or high tension current above given, it is clear that if the ebonite, wax, or silk inside the coil box should get cracked, melted, or displaced, or if the rubber on the high tension wire should get abraded or leaky, the spark is liable to occur at the new weak spot instead of in the cylinder. This results in a failure of the ignition, to the great displeasure of the motorist, who must either localize and cure the defect or submit to the annoyance of misfires or even of a total stoppage.

These and many other possible causes of breakdown are dealt with under Missing Explosions, Fault Finding, etc. For Batteries, and their management, or for Induction Coils, the reader is referred to the articles where these devices have been dealt with under their own names.

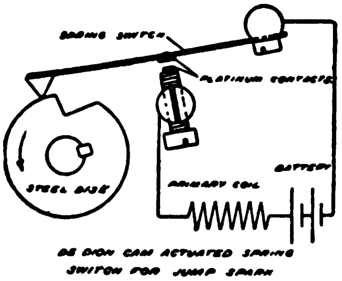
4. The Circuits—From what has been said above, it is clear that there are two circuits for all high tension systems.

(A) The battery circuit, called primary circuit.

(B) The spark plug circuit, called secondary circuit or high tension circuit.

Unlike our usual ideas of the flow of water which will pass from a tap to a drain when the tap is turned on, electric current will not flow from one point to another unless these two points are in the path of a completely-closed circuit.

If we effectively interrupt the continuity of any closed circuit, we stop the current in that circuit, no matter at what point the interruption may be made; that is why turning the control switch stops the entire ignition system and therefore the car.



Details of Primary Circuit in the De Dion System.

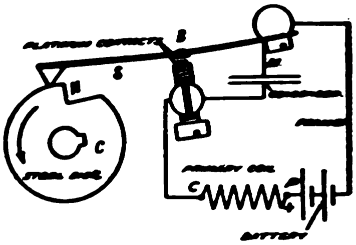
5. In the primary circuit of an ignition system, a man swimming with the electric current inside the copper conductor, would, if he started from the + pole of the battery, follow the wires and pass in turn through—

(a) The + terminal of the battery.
(b) The control switch.
(c) The terminal in the coil marked P or B.
(d) The primary winding on the coil.
(e) The trembler blade.
(f) The platinum tipped screw.
(g) The terminal on coil box marked C.
(h) The commutator brush.
(i) The brass commutator contact piece.
(j) The frame of the car.
(k) From the frame to the ground wire.
(l) To the negative pole of the battery.
(m) Through the battery liquid and through the plates till he returned to
(n) The + pole of the battery.

When swimming in the tortuous wire of the primary winding of the coil, he would notice if he were empowered to see through the silk, ebonite and wax insulation, that he is very near to the secondary winding of the coil, called the high ten-

sion winding, but the primary circuit never comes into contact with it save at one single point, viz., the binding screw C on the coil box.

6. The Rotary Contact Maker or Breaker—If a sequence of sparks were required to continue without any measured interval of time elapsing between them. this device would not be wanted, as the trembler blade is quite sufficient to secure a constant shower of sparks, but in order only to fire the mixture at the right time (namely, when the compression is about complete) the primary current is only allowed to flow at the appropriate moment by the rotary contact maker which



Position and Connections of Condenser When Coil is Not Fitted With a Trembler Spring.

is arranged to be driven by the engine camshaft at half the speed of the engine and is adjusted to make contact only at the precise instant when sparks are wanted. See Timing.

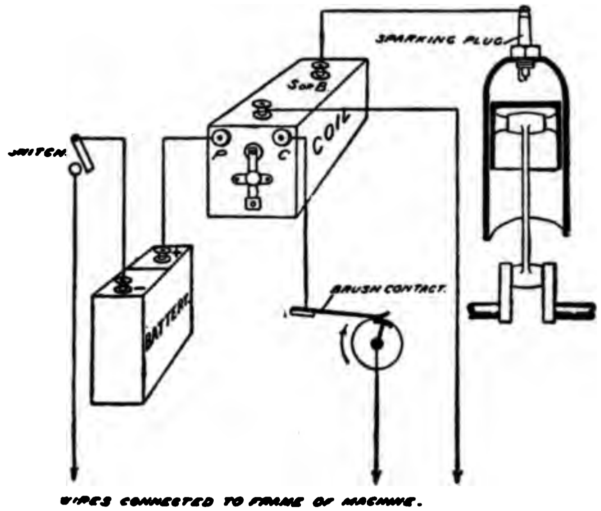
7. The Trembler—As the rotary contact make-and-break closes the primary circuit and then a little later interrupts it, the condition necessary for the induction of a current in the high tension circuit is complied with even without the use of a trembler. The object of the trembler is merely to cause a large number of additional "makes and breaks" of the circuit at a much higher rate of breaking the circuit, that is, with more suddenness than is effected by the slow moving rotary contact maker. So true is it that the trembler is not strictly necessary that many ignition systems dispense with it, but in return those systems have to provide that the rotary contact maker has platinum points and other peculiar features to secure a very much more rapid action than the

slow "wipe" (as it is called) of a brass brush against a brass contact piece. When a trembler is mounted on the coil it is usual to distinguish the coil so equipped by calling it a "trembler coil."

8. The value of a rapid break of the primary circuit is very great in improving the intensity of the spark in the high tension circuit.

9. The High Tension Circuit or "secondary circuit" is extremely simple. The high tension current flows:

(A) Through the high tension winding on the coil, in which it is generated by induction in a spasmodic manner every time the primary circuit is (a) closed rapidly; (b) broken rapidly.



Complete One-Cylinder Ignition Diagram—Battery and Coil System with Trembler Blade.

(B) It passes through the insulated terminal of the coil.

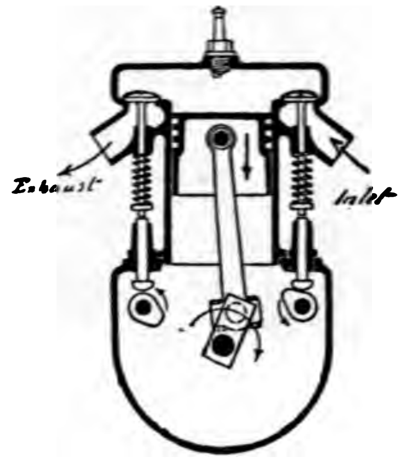
(C) Through the high tension wire, which is covered with an extra thick coating of rubber.

(D) Through the binding screw on the spark plug; down the central stem of the spark plug.

(E) It jumps as a spark across the spark gap.

(F) It flows round the casting which forms the engine cylinder to the car frame and back to the other end of the coil, where usually the secondary winding is connected to the primary winding (making use on its way of the rotary contact-breaker in the primary circuit, which simply acts as a "ground" connection, that is, a connection to the frame of the car).

10. A great deal of the apparent intricacy of the electric gear in a car is due to the fact that the wires are necessarily invisible through a part of their length (when they enter each piece of apparatus).



Position of Valves, Valve Cams, Piston and Crank When Spark Has Just Occurred.

Thus, although the wiring diagrams may be clear enough, the least departure from the arrangement shown by them is apt to puzzle a beginner. As an exercise he should examine other diagrams and trace in them the primary and secondary circuit lines of travel.

11. Ignition for Several Cylinders—So far a single-cylinder engine ignition has been dealt with for the sake of simplicity. For more cylinders the whole system could be re-duplicated

once for each cylinder with satisfactory results, save that a simpler and cheaper method can be got by using:

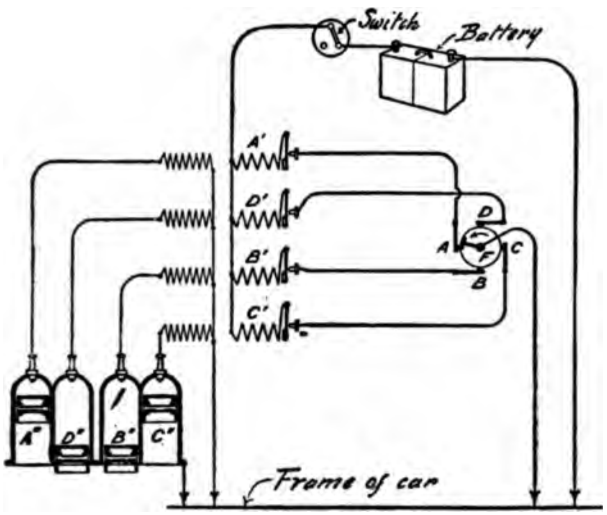
(a) One battery for all the circuits and as many trembler coils as there are cylinders, or, simpler still—

(b) One battery and one trembler coil only for all the cylinders.

Both (a) and (b) are in every-day use.

The cases where a non-trembler coil is used for one or several cylinders are dealt with later in this article.

12. Ignition from One Trembler Coil to Several Cylinders —In this case the electrical connections of the primary circuit are substantially the same as when one coil is used to make a spark in one cylinder, save only that instead of there being only one closing of the circuit by the brass brush pressing on a brass segment once for each revolution of the contact maker, a number of contacts are wanted, and therefore a number of segments are introduced, one for each cylinder.

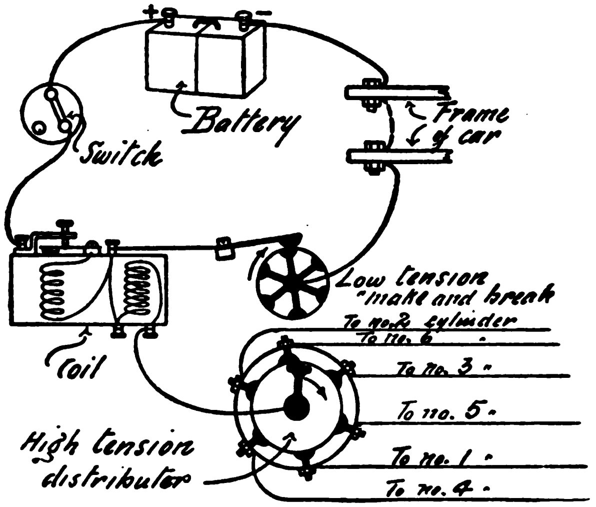


Connections for a Four-Cylinder Ignition, with Four Trembler Coils But Only One Battery.

13. The high tension current is directed to whichever

cylinder requires a spark, by a high tension distributer. This consists simply of a carefully insulated central arm, which rotates with the contact maker to which it is mechanically coupled. This arm comes very close to each in turn of high tension terminals arranged in an ebonite supporting ring at approximately the same moment as the brush touches one of the contacts. Obviously if six, four or two cylinders are used, there are only six, four or two high tension terminals and also only four or two contacts in the rotary contact-maker.

14. High Tension Distributer—In all cases where a high tension distributer is used, the leakage of the high tension current from terminals along the exposed ebonite surfaces must be carefully guarded against by keeping the parts scrupulously dry and clean. If the rotating arm were to make a rubbing contact against the terminals metallic powder would be liable to be spread over the ebonite ring as a thin conducting film, hence it is usual not to allow the arm to touch the



Ignition of Six-Cylinder Engine From One Trembler Coil and One Battery.

terminals, but merely to come very closely to them. The high tension is sufficient to force the current to jump this small distance on its way to the spark gap. This small "jump" constitutes effectively what has been termed a spark "intensifier." See Intensifier.

15. High Tension Ignition by Dynamo—Where it is not easy to get batteries recharged these are sometimes—but rarely—dispensed with by employing a little of the power of the engine to generate on board the car the electricity required as and when it is wanted.

In this case, besides the waste of power, which is comparatively slight, there is also the minor drawback that the engine will not start on merely turning the switch, even though it have four or more cylinders unless a supplementary battery be carried for starting.

The dynamo may be driven from the engine by spur, chain, belt or friction gearing. In the case of one make of dynamo the gear ratio has to be such that the armature will run at about 1,400 revolutions per minute, and an automatic clutch governor is provided which allows the dynamo pulley to slip, and so prevents the speed from exceeding that amount. Another reason for having a battery as well as a dynamo is that, unless the engine can be turned by hand at such a rate that the armature revolves at at least 400 revolutions per minute for a dynamo, or 200 revolutions per minute for a magneto, a separate source of electricity supply has to be used at starting. Such a source may be dry batteries or accumulators, of which alternatives the former is most to be recommended (if used for starting purposes exclusively).

There are two methods of installing the dynamo system:

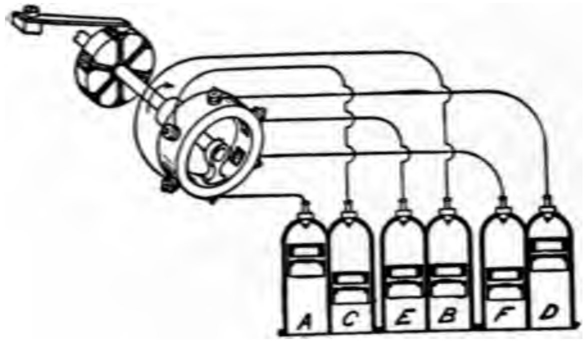
1. To connect the dynamo terminals direct to the ends of the primary winding of the induction coil.

2. To connect the dynamo terminals to a storage battery so that the current from the dynamo is used merely for recharging the battery.

The first method is usually arranged to give about 12 volts to the primary circuit under normal conditions. The elec-

trical connections are exactly the same as if the dynamo were used instead of the accumulators.

The second method has the advantage that the accumulators are kept continually charged, and it also provides a spare source of electricity, for should the accumulators fail, the dynamo may be connected up as above. On the other hand, should a failure of the dynamo be detected, the accumulators are ready charged.



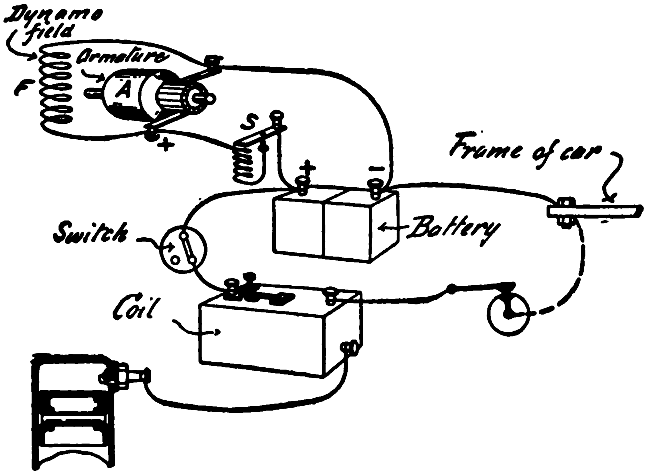
High Tension Connections of a Six-Cylinder Distributer for Ignition From One Trembler Coil.

16. High Tension from Magneto Machines.—The term High Tension Magneto Ignition is generally applied to one of several systems in which some special feature is introduced. See. Magneto.

The chief reason for the introduction of the magneto system is found in the disadvantages of storage batteries. These may be briefly summarized as follows:

Weight, volume, brittleness of case, overflow and spillage of acid, susceptibility of becoming exhausted without giving warning, low internal resistance, difficulty of identifying the polarity of the terminals, difficulty of knowing whether battery is charged or not, delay of recharging, deterioration by mere waiting—sulphating, buckling of plates by rapid discharge (objections to buckling), difficulty of transport by rail or express, etc., falling out of paste in course of legitimate use as well as by abuse; unsuitableness of lead to stand vibration, that is, breakage of lugs.

A brief review of the principles underlying this system of ignition may be given. In the first place, it is impracticable to generate electricity at high tension direct from the magneto machine, so that all magneto systems use the magneto to generate low tension current and an induction coil to convert it to high tension. Roughly speaking, the magneto takes the place of the battery or dynamo in the systems previously described, but as the current obtained is of an alternating character instead of continuous, the rest of the ignition apparatus is modified to suit the new conditions.



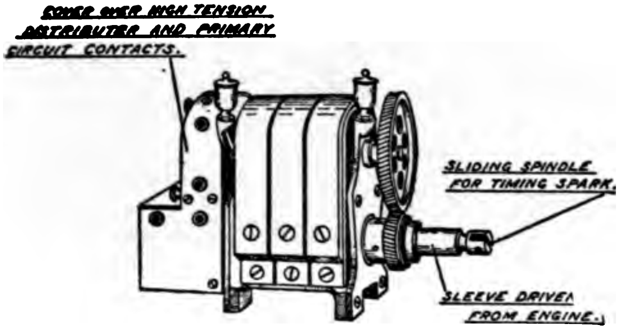
Dynamo and Batteries Together in One Ignition System.

The production of a current by a magneto, and the production of the current in the secondary winding of an induction coil, both depend on the same fundamental phenomenon, namely, that a current is "induced" in a wire or coil of wire which is exposed to the influence of a magnetic field of varying strength.

In magneto machines the magnetic field is provided by steel "permanent" magnets between the poles of which a coil of wire is placed, and the variation of the magnetic field or "flux" is obtained either by rotating the coil of wire or by moving an iron core in the field.

This coil of wire with its core is called the armature.

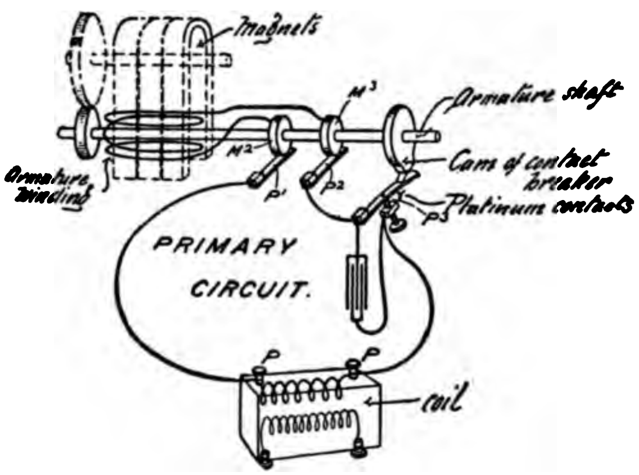
In the case of one type of magneto (the Bosch) the "armature" and permanent magnets are stationary, and the variation of flux through the armature coil is caused by revolving or reciprocating a soft iron shield in the space between the armature and the magnets. So far as the resulting electricity is concerned, it does not matter whether there is a revolving armature or a reciprocating or revolving iron shield. The final result is the production of electricity at low tension in the armature windings which form part of the primary circuit, and the problem to be solved by the designer of high tension magneto apparatus is to convert the low tension to high tension and then distribute it to the cylinders, there to generate sparks at exactly the right moments, no matter what the speed of the engine may be. It will be obvious to any one who has read the foregoing matter on ignition that a primary and secondary coil is required, and these may be mounted in a coil box as hitherto, as in the Eisemann, or induction coils may be built up on the armature, using the armature winding as its primary and the armature bobbin as its core, as in the Bosch and others. The next necessary adjunct is a contact breaker in the primary circuit arranged to


COVER OVER HIGH TENSION DISTRIBUTER AND PRIMARY CIRCUIT CONTACTS.
SLIDING SPINDLE FOR TIMING SPARK.
SLEEVE DRIVEN FROM ENGINE.

Eisemann Multiple Cylinder Magneto.

open or break the armature circuit with great suddenness when the current is at its maximum value. The third principal part is a high tension distributer whose function it is to distribute the sparks to the cylinders. Lastly, some facility is almost always provided for altering the timing of the ignition at the will of the driver. It is in the finding of means to all these ends that the differences arise between the various systems. See Magneto.

17. Low Tension Ignition.—This system is falling out of use in some cases and being newly adopted in others. Its advantages are the great amount of heat which can be provided at the spark and the simplicity of the electrical circuit. Its most serious drawback is the introduction of moving parts into the cylinder, which gives it an appearance of complexity. There is further some difficulty in insuring accurate timing in multi-cylinder engines, if the moving parts of the ignition gear do not wear evenly. Nevertheless, more power can probably be got from a given cylinder volume and from a given quantity of gasolene with this form of igniter than any other commercial method.



Primary Circuit of Magneto System (Eisemann).

When a circuit carrying a current is broken a spark occurs at the point of breaking. The intensity of the spark from an accumulator is much greater if the circuit possesses a "self-induction" coil. If the source of current is a magneto, the armature winding is effectively a self-induction coil. No supplementary coil need be used.

A typical Bosch low-tension magneto is geared to the engine so that a soft iron shield oscillates between the fixed armature and the magnet pole pieces. The oscillation of the shield varies the magnetic flux through the armature winding, and so induces an electric current in it.

In the rotary type of this magneto there are four points per revolution of the shield when the induced current is a maximum, and four points when it is zero. To obtain a spark it is, of course, necessary not to break the circuit when the current is zero; the spark will be best if current is broken at or near one of its maxima. This is effected by means of a cam, tappet rod and contacts.

The actual contact is broken between a lever and a stud fixed inside the head of the cylinder, the suddenness of the break being due to the strength of spring and the steepness of the notch on the cam which actuates the tappet rod. Immediately the circuit has been opened it is closed again by the action of a spring.

The electrical connections consist, as far as the user is concerned, of one wire from the magneto to the insulated terminal in the cylinder.

In another system the make-and-break in the cylinder is effected magnetically, so as to dispense with rod and spring. The spark advance is effected by the ingenious method of rocking backward the permanent magnets, and so obtaining the maximum voltage at an earlier moment.

IGNITION FAULTS AND HINTS.

If electrical matters are not your forte, ignition is a likely point of failure; hence the first thing to do when the engine unexpectedly refuses to give the regular beat of its explosion is to see whether you obtain a spark between the frame of the machine and the insulating cap of each sparking plug when the engine is turned by means of the starting handle through one or two complete revolutions (of course with mixture cut off and compression released where provision for this is made in the machine). See Missing Explosions.

When doing this connect one end of the copper of a thickly insulated wire to the frame of the machine and place the other end very close to the exposed binding screw or brass cap of the spark plug; if you get a good spark you may be almost sure that the ignition is not the cause of the stoppage. If you cannot get a piece of insulated wire, a key or a spanner will do as well, provided you are careful to avoid getting a shock by keeping the metal of the spanner well grounded—that is, in contact with the frame. If you get either a fat spark or a strong shock, the ignition is probably all right. If you greatly dread a shock, undo the high-tension wire, and, holding it by the rubber insulation, try the high-tension spark, which should be about ½ inch long in air and very bright. Special terminals are made for the rapid disconnection of the high-tension wire for this purpose. There are, however, five cases in which you will obtain a spark or a shock, although the ignition is the cause of failure.

The first case is when the battery is practically empty, but has had time to recover in a temporary manner owing to the stoppage of the car. You will probably find that the engine will re-start and only run a little way. The only cure for this is to have a second battery, which should be switched on with a two-way switch.

The second case is when some one of the wires of the system is making a bad connection or is partially broken. In this case the running of the car will shake the broken or loose parts asunder, whereas the stationary car may give you a satisfactory spark. The quickest cure for this in the long run is not to hunt for faults, but to tighten one by one every binding screw and turn the handle again. If this does not cure it, pull out one by one every wire in the car and replace them with your spare wires. The reason for not hunting out the fault is that the break has probably occurred within the thickness of the insulation itself, and is not discoverable without instruments or, at any rate, a tedious search.

The third case is when the two points of the spark gap within the cylinder are too far apart, or have too much oil, soot or moisture on them to allow a good fat spark to occur within the cylinder. Remember that a spark does not occur with the same ease in the compressed gas of the cylinder as it does in the open air.

Fourth.—It is possible that the porcelain or mica insulator of the sparking plug is cracked or allows the current to flow through it. This is cured at once by inserting a spare plug.

Fifth.—If the high-pressure spark appears to be thin and weedy, so that you suspect it of not being hot enough to ignite the gas within the cylinder when under compression, it is probable that one of five things is the cause—

1. The battery has run down.
2. The trembler blade and its platinum contacts are out of adjustment.
3. There is grease or oil upon the make-and-break spring, if a non-trembler coil is in use.
4. The condenser has somehow become disconnected or punctured.
5. The high-tension windings on the coil or the high-tension wire have partly broken down their insulation.

Therefore, switch over to your spare battery; clean the platinum points of your spring contact by rubbing a visiting card between them or even by smoothing them out with a very fine file and removing all filings very carefully. The condenser trouble is not curable on the road, but you may be able to run your engine slowly home if you allow the compression cock to leak a little. If touring in remote parts it is worth while to carry a spare coil or even to have a complete stand-by ignition.

Damp.—Water is a conductor of electricity; therefore the porcelain plug should be wiped after a damp or foggy run. The rubber-covered wires where they approach the terminals should also be kept dry. This will be found impossible if there is any exposed braid or tape to get damp and to collect and retain it. Therefore, remove the braid and tape from the end of all wires for a length of about an inch close to the terminals. Do not remove the braid from the entire length of the wire, because it is a useful protection against breaking and fretting, but dip the whole of the braided wire before using it into a bath of melted paraffin wax, wiping off the surplus. See Repairs and Adjustments.

Supposing that neither a spark nor a shock is obtained at the spark plug of the cylinder which is misfiring, it is generally safe to look in turn for one of the following defects:

(i.) The battery completely exhausted (try it with a voltmeter which takes the full normal current, say 1 ampere).

(ii.) There is a disconnection or a break in a wire—examine first the high-tension wire as being the simpler. See also that the switch has not accidentally been moved to the "off" position. See that the lead lug in the battery is not broken.

(iii.) The platinum tip has fallen off from the trembler blade or from the spring contact, or from the platinum-tipped screw; or the entire trembler blade has come loose from its clamp.

(iv.) One of the coils has completely broken down. If so, the click of a spark is generally audible by putting one's ear close to the coil-box.

In applying these various suggestions the reader is credited with a certain amount of acumen. Thus he will at once surmise that if only one of four coils fails to give a good spark it clearly cannot be the battery that has failed; indeed, trouble in this case is not to be expected in any part which is common to the whole four coils, as, for example, the ground wire, or the switch, or the commutator, save at the one contact corresponding to the one cylinder showing the faulty ignition.

Cleaning Sooty Plugs.

With a two, three or four-cylinder motor, it is quite possible to clean a sooty ignition plug without removing it from the cylinder. The "modus operandi" is as follows: Detach the high-tension wire from the misbehaving plug, open the compression cock of its cylinder, and run the engine on the other cylinders. Then hold the terminal of the detached wire, being very careful not to touch the metal part with the fingers, a very short distance off the end of the plug, so that the spark jumps to the latter. The wire should be held by the insulated part at least two inches from the bared terminal. At first the cylinder will be heard to be missing, but very quickly the reverse will be the case, and the dirty plug will be found to have cleaned itself, as to all intents and purposes a spark gap is established. Then switch off, shut your compression cock, attach your wire again, and start up.

How to True Up the Contact Screw.

In devising a jig for trembler screw points, the simplest possible form, if there is no difficulty in getting either a "tap" which will fit the trembler screw, or in cutting a tap to do so, all that is necessary for the trembler screw device is to drill and tap a hole through a piece of $\frac{1}{8}$-inch steel plate, ground perfectly true on one face, and then harden the plate. The hard, flat face acts as a guide for the file, insuring that it travels truly in the same plane, and the fact that the trembler screw is held by its own thread is a guarantee that the face of the point is at right angles to the line of the screw. This way of doing the point is the simplest, but supposing the trembler screw cannot have its thread matched without trouble and expense, the jig illustrated in Fig. 1 obviates any difficulty in this direction. It consists simply of a piece of cast steel bar, bent round as shown, and having the face marked D ground quite flat. Through the center of this portion of the bent steel a hole is drilled, which is exactly the size of the outside of the trembler screw, so that it will just push in from the under side easily. In the illustration a slice has been cut out in front of the trembler screw A so that it can be seen. Exactly opposite this hole in the other arm of the bend, a second hole is drilled and tapped with any convenient thread. Through this hole the round-ended set screw B is inserted, its rounded end bearing beneath the milled end of the trembler screw. The steel bend and the screw B should both be hardened. To use this jig the trembler screw is inserted, and the lower set screw B run up until the contact point C can just be seen, on glancing along the face D, to be sufficiently above that face to clean up quite flat. A fine flat file then steadied along the true face D will complete the operation, and a perfectly level surface will be obtained for the point C.

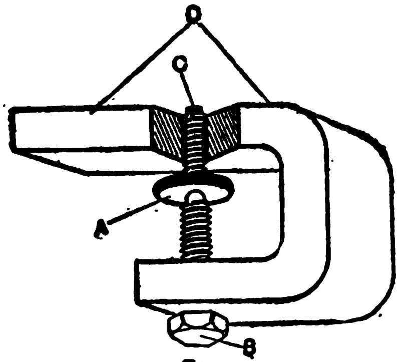


Fig. 1.

Jig for filing trembler screw points correctly.

A, trembler screw. C, platinum point.
B, adjusting screw acting as a stop. D, hardened flat face.

Truing Up the Blade Contact.

The jig for the trembler blades illustrated in Fig. 2 consists of a cruciform base, the central portion of which is bored and screwed to receive the circular table A. This table, which is shown separately in the left-hand corner with its shank in section, is made with a buttress thread as shown, and preferably its edges should be knurled or milled. Along one diameter of the base, and equidistant from the center of the table

A, are the screwed studs D D, which pass through holes in the two clips C C. These clips are as shown, and consist simply of two metal strips about ¾ inch wide and $\frac{3}{16}$ inch thick, bent over at the one end, and ground flat on the down-turned face opposed to the top of the table A at the other. Along the other diameter the studs or stops B B are fixed, these being screwed into the base and made from hard steel. The upper faces of these studs B B must be perfectly level, and exactly the same height from the base plate.

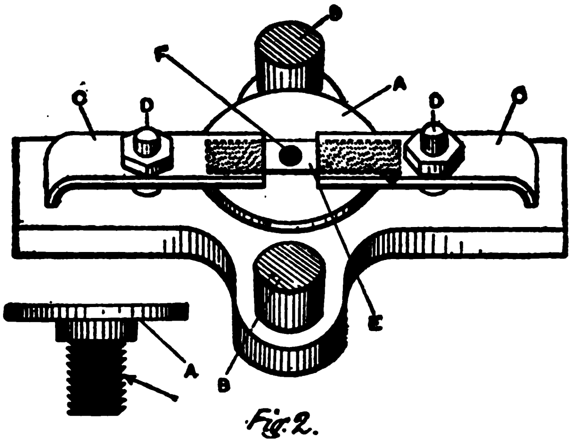


Fig. 2.

Perspective plan view of jig for filing the points of trembler blades flat.

A, adjustable table with buttress threaded shank.
B B, hard steel studs for grinding the file.
C C, clips holding blade to table.
D D, studs and nuts for tightening clips.
E, trembler blade.
F, platinum point.

The method of procedure is as follows: The trembler blade E is laid down on the table A with the platinum point F upwards. The clips C C are slipped over, so that the trembler blade is between the lower faces of the clips and the table top, but the nuts on the studs D D are left quite slack. A straight-edge is then held across the faces B B, and the table screwed up until the point F comes into contact with it. The straight-edge is removed and the table taken up just a shade more, according to how much has to be removed from the platinum point F. The nuts on the studs D D are then tightened down gently, when the blade is gripped firmly against the surface of the table; and, moreover, since the table has a buttress-threaded shank, the pressure locks the table very securely in position. A fine file is then run across the studs B B, with the result that the point F is made quite flat and true with the blade in both directions.

Two steel plates, identical in shape, which can be clamped together by a pair of thumbscrews, and having a 3/8-inch hole drilled completely through the two, make an excellent jig for holding the end of the trembler blade when filing the hole to secure coincident setting of the points, this obviating straining or bending.

Adjusting Contact Breaker Screws.

In adjusting the contact breaker screws when the contact breaker is of the positive make-and-break type, care should always be taken to see that the small locking screw, which is provided in the split end of the screw-supporting pillar, is properly locked after the adjustment is complete. Also, it should be noticed whether locking up this screw affects the adjustment of the contact screw, as this sometimes happens. When the contact-making screw is not properly locked up, the constant tapping on it of the trembler blade invariably works it farther back, so that the adjustment does not keep correct for any length of time, and, consequently, the annoyance of misfiring is experienced very frequently.

A Cause of Irregular Firing.

Automobilists who have had experience with the old De Dion type of contact maker have at some time or other been troubled with irregular firing of the cylinder charge. This has been put down to various causes, chief of which, no doubt, has been a dirty contact between the platinum-pointed adjusting screw and the trembler blade. Other causes are loose contacts, either at the plug wires or in the primary circuit, dirty sparking plugs, nearly run-down battery, or a bad mixture.

A not infrequent cause of trouble, however, is due to the fact of the hole in the insulating quadrant of the contact maker itself wearing slack or oval. The constant knocking action of the notched cam on the trembler V-piece in time causes an oval hole in the quadrant, and consequently the correct action of the trembler is interfered with, and frequent adjustments of the screw become absolutely necessary. When the quadrant wears oval, it can be repaired by bushing it with gunmetal, but probably a more satisfactory method would be to fit a new contact maker.

A more lasting quadrant would be one made entirely of metal, a good hard gunmetal for preference, in which case the adjusting screw terminal and connections would have to be insulated by means of wood fiber or ebonite washers, and there would be no necessity for a ground wire to be the trembler terminal, as it would be constantly grounded through the metal quadrant. This has been employed in certain cases, and has given every satisfaction.

Trembler Contact Treatment.

When coil tremblers are behaving badly and require filing, it may happen that a suitable file is not at hand. Then a fairly good new surface can be obtained on the platinum end of the screw by tapping it lightly with a small smooth-faced hammer.

Loose Contacts and Faulty Firing.

A case is reported of a somewhat curious source of trouble in connection with a two-cylinder engine. The engine suddenly refused to fire, and after much trouble and delay in testing wires, etc., the fault was found to be ascribable to a loose platinum tip in the trembler adjusting screw. At first sight the platinum showed about one-sixteenth of an inch clear of the end of the screw, but when tapped with a hammer it disappeared entirely within the screw. The trouble disappeared altogether when a new screw which had its platinum point quite firm was fitted.

Trembler Fatigue.

It is pretty certain that ignition troubles are occasionally caused by trembler fatigue. A case in point which once occurred to a motoring authority would go to prove this. His engine would drive for from forty to fifty miles perfectly, running the car up all ordinary grades on its fourth speed; but shortly after that distance had been covered, one of the cylinders would begin to fire irregularly, and nothing would improve it. Coil trouble was suggested, but he was loth to believe this was at the root of the evil. The erring cylinder would not drive the crankshaft alone, when the tremblers of the other three cylinders were prevented from vibrating, although either of these three would perform fairly well by itself. No sooner was a new trembler fitted than the aforesaid weak cylinder ran merrily by itself, and the owner was moved to replace the remaining three old tremblers with new ones. These replacements greatly improved the firing and pull of all the cylinders, so that he was forced to believe that the old tremblers, which had been in constant use for eight months, wanted a rest.

Pitting of Trembler Contacts.

An annoying trouble, which in many cases is only a too frequent occurrence, is the pitting of the platinum contact on the trembler blade on high-speed trembler coils. The coil will sometimes work fairly well at slow speeds, but gives frequent missing when the engine is run at its normal rate, or accelerated. On examination of the platinum points mentioned, it is found that the screw appears to have its end melted in the form of a rough cone, like the carbon of an arc lamp, while the platinum on the blade is eaten out cup-shaped similar to the second carbon. It would therefore appear that the metal was volatilized at one point and deposited on the other. The probable reason for this may be the use of an inferior platinum alloy, which has a comparatively low melting point, and is, therefore, more readily volatilized than pure platinum. Pure platinum does not stand the rapid knocking at the high speeds the trembler works at, and hence an alloy of platinum and iridium is largely used, and this probably follows the rule that the melting point of an alloy is lower than that of either of its constituents.

In many cases frequent adjustments of the trembler screw and trimming up of the points only cure the trouble for a time, and lead to the conclusion that there is also some inherent fault in the coil itself.

Extra Grounding Wire.

"My 5½ H.P. single-cylinder engine had always been a trouble to start, but once going would run well," writes a European motorist. "Complete rewiring, a new sparking plug, shifting the non-trembler coil nearer to the engine, and a general clean up of all the electrical fittings did not improve matters. Finally, a second ground wire was attached to the coil, ending at the blade of the contact breaker, and the engine now starts without hesitation. The question now is, Why was the first ground wire ineffective? It was a good wire from the coil to a bolt holding the engine to the frame of the car. The platinum-tipped screw is insulated, but the trembler blade is attached to a metal segment moving about the half-time shaft as usual. The only explanation I can give is that the thick oil from the crankcase proved an insulator, a film of this lying around the half-time shaft between it and the metal segment. While the engine was at rest this oil more or less set hard. Upon trying to start the engine, it was necessary, by a long period of starting handle exercise, to wear through this film of oil until the one metal surface of the half-time shaft rubbed against the other metal surface of the segment. This has now been saved by giving an alternative path direct from the blade to the coil."

The Trembler Coil.

Many motorists would be glad to have an explanation of the reason why a trembler coil is necessary with a wipe contact, and the difference between an ordinary coil without and the coil with a trembler. To summarize the reason, it is necessary to break up the primary circuit of the coil rapidly—that is, the current which flows from the source of electrical energy through the coil. This interrupts the lines of the magnetic field, and intensifies the power of the induced current, for the quicker the make and break at the trembler, the more effective is the spark, or, rather, the shower of sparks, at the plug, such a shower being much hotter than those of lesser density produced by a slow vibrating trembler. That is why, as a rule, the magnetic trembler is much more effective than the mechanical trembler, for the latter cannot work up to the speed of the former.

A Cause of Misfiring.

An engine, after being in use for some time, will often misfire, and the cause be difficult to ascertain. Frequently the trouble is one which does not occur with a new engine. If the contact breaker is of the make-and-break type, the bearing of the contact maker may have worn and the current find difficulty in reaching "earth." To obviate this, a stranded wire, which need not be insulated, may be led from some part of the motor to the screw which holds the trembler blade in place. Then the current travels directly from the trembler to the earth without having to go through any sliding joints. etc. In a wipe contact maker, it will be often found that the brass is worn flush, or lower than the insulation, the result being that the wiping blade jumps the brass at high speeds. The insulation can easily be removed near the brass, which will cause it to operate as before. Contact breakers of this type should always be oiled, as it prevents the wiping blade carrying the insulation on to the brass, which it frequently does owing to its wiping action, the result being misfiring at high speeds. Again, misfiring such as this is often due to the wiping blade having lost its stiffness, and not bearing sufficiently hard upon the contact breaker cam, which may have worn as well. See Missing Explosions.

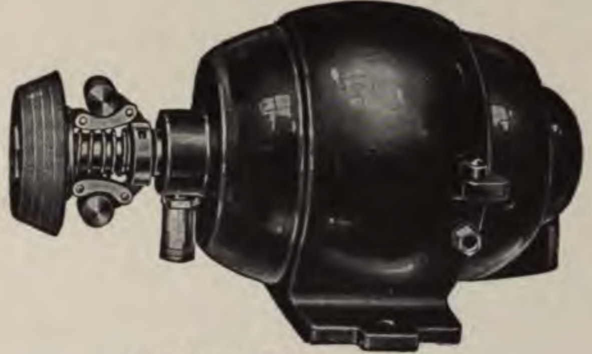
Misfiring Through Defective Insulation.

Much annoyance is often caused to the user of a motor car by occasional misfiring which he finds a difficulty in locating. We cite a case of this kind, where for a time the engine would run perfectly, and then most unaccountably commence to misfire. This alternated with periods of regular running and irregular running. A thorough examination revealed no defects—the battery was fully charged, coil worked perfectly, and the contact maker made good contact—but still, as stated above, trouble was experienced repeatedly. It was noticed, however, on turning down the front of the coil box, that the high-tension wire of one of the coils was brought very close to the low-tension wire of the other, and the owner found that, instead of this high-tension wire being thoroughly protected by its insulation, at intervals a spark would leap through the insulation to the low-tension terminal before mentioned, and a misfire thus be caused in one of the cylinders. Removing the wire to a distance of about half an inch from the other terminal immediately corrected the fault, and no further trouble occurred.

In such cases of misfiring it is always advisable to inspect all wires which touch a metallic part of the frame, as, owing to the vibration of the engine, the cause may be at these points.

Marks on French Induction Coil Terminals.

The marks upon induction coils of French manufacture are not understood by a great many users, and therefore an explanation of them may be of interest. There are usually three terminal screws upon the coil for a single-cylinder engine, and these are marked P, M and B; P and M usually being at the side of the coil at the top, and B either directly at the bottom or lower down on the side. The terminal marked P is connected to the positive terminal of the storage battery by an insulated wire into which the contact breaker is interposed. There are, of course, many variations in the wiring of the connections to the coil, and the one given herewith is only one of them. The terminal M, which, by the way, on some French coils is also marked V, is connected to some metallic part of the frame on the car, or to the engine itself, and forms an earth or ground return to the negative terminal of the battery, a further piece of wire being connected from this terminal to the framework to complete the circuit.



The Apple Ignition Dynamo.

Dayton 14-S. Switchboard. Apple Storage Battery.

THE APPLE IGNITION SYSTEM.

The Combat Igniter.
(Storage Battery.)

Bosch Low-Tension Magneto for
Two-Cylinder Cars.

The terminal B is the one to which the high-tension wire connecting up to the plug should be attached.

Numbering the Coil.

On three and four-cylinder engines fitted with trembler coils, it is always well to take an early opportunity of verifying the trembler for each cylinder. For instance, assume that a four-cylinder engine is missing on one or two cylinders. The bad cylinder is ascertained by holding down the trembler blades and making the engine run on one cylinder at a time. When we come to the bad one, the engine stops unless the other blades are quickly released. Despite this we find that all four tremblers are buzzing merrily in turn, and apparently there is nothing wrong with them. It is therefore natural to assume that the plug is at fault, and the question at once arises, which plug? There is nothing for it but to unscrew them one by one, and to turn the engine round to see if the one under examination is sparking out of the cylinder. In the usual course of things it will be the last plug one takes out which is found to be foul or otherwise at fault. On the other hand, if we had known which buzzer belonged to each plug, we could have gone straight to the foul plug and have cleaned it up or put in a new one without loss of time. However, as we have got our four plugs out, we might just as well count them off from the front. Call the one nearest the radiator No. 1. Turn the engine round slowly, and when you see the plug on No. 1 sparking, go round to the trembler coil and see which of the four tremblers is buzzing. Then pencil on the trembler case opposite to this trembler No. 1. Continue the operation until you have numbered the coil for all four cylinders. Of course, we know the engine does not fire 1, 2, 3, 4 backward, but that does not matter; we only suggest numbering the coil so that it can at once be seen which trembler and which plug are connected, so that in future, whenever there is a cylinder not firing, we can safely assume, when we have played the usual four-finger exercise on the coil, that the plug on a certain cylinder is wrong. We no longer need blunder through all four.

General Troubles with Coils.

Looseness of platinum screws in the bridges.—Whether these are bound with a lock-nut or not, they offer resistance to the primary current.

Armature rubbing against the guide screw.—This restricts the speed of the armature. Allowance is made for this in some armatures by making the hole in the armature through which the binding screw passes slightly larger than the screw stem.

Shorting of the secondary current to the coil support angles or ears, due to the screws which hold the angles to the case being too long and projecting inside.

In the case of four-cylinder coils (not waxed in entirely) the ebonite top breaks away, owing to the screws which are passed through the case into the ebonite top chipping out pieces of ebonite, and so losing their hold of the top. This is very often caused by the windings getting loose, and may be caused by a jar to the coil.

Breaking of the primary wire between the communication screws on the ebonite top and the terminals, and between the communication screw and the bobbin itself.

Breaking of the flex wire between the bobbin (high tension) and the terminal.

Internal switch troubles, due to wax entering the switch and greasing the metal contacts.

Buttons on the armatures (which draw down the platinum blade) getting loose and causing erratic striking of the platinum blade. In the case of some distributer coils this may be the cause of knocking in the engine.

Button of the armature shorting on the platinum screw.

Stiffness of the distributer armatures—in those cases where it is of springy material and has no spring underneath to help its return movement. This stiffness causes misfiring at high engine speeds.

Many owners have had cases of coils bubbling the wax out. This has been in most cases where ordinary coils have been used for distributer purposes. They have noticed also that with certain distributer coils with the bobbins waxed separately all the insulation off the bobbin melted down to the bottom of the box. This probably was due to the coil being placed inside the bonnet near the engine.

In large heavy two, three and four-cylinder coils the wooden cases have split, especially where angles are screwed to the wood. As an opposite example to this, the case is cited of a four-cylinder coil where the wood of the case and front flap was half an inch thick. It looked a very substantial coil, and would probably stand rough usage. The top had hinges, and front flap hinges were also much stronger than usual. Where flaps in covered-in coils are used the hinges are often loose. The same applies to the top lids. This is accounted for by the thin wood used in the case construction, which necessitates small screws being used to screw on the hinges.

Commutator Short Circuiting.

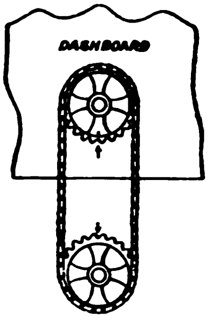
Good as rolling contact commutators undoubtedly are, yet nevertheless trouble may arise from them and within them which the automobilist may be long in diagnosing if he has not been informed that its happening is within the bounds of possibility. After considerable use, the friction of the roller over the metal contacts has the effect of wearing off small particles of the metal and gradually laying these on the fiber ring in the form of an embedded train, which will ultimately connect one contact with the other, so that the current will short all round, and whether two or four cylinders are served, current will pass to all the sparking plugs at once. If this has happened, the only thing to do is to detach the fiber ring and scrape the inlaid metal from its surface. These remarks apply with even more force to the commutators made on similar lines, but which have a rubbing in lieu of a rolling contact.

A Mysterious Squeaking Noise.

Sometimes a motor will develop a mysterious squeak when running, and this often takes a good deal of locating. Many motors are fitted with the wipe type of contact maker, and it is well to look to the wiper blade and the disk on which it rubs for the source of the squeak. If the disk is allowed to get dry, a most distressing noise is caused by the rubbing of the steel wiper piece on the fiber of the disk or by the bearing of the roller on the wiper arm when the latter is rotated. A spot or two of ordinary lubricating oil will effectually cure the trouble.

Adjusting Commutator Chain Drive.

If a chain-driven commutator upon the dashboard is used, it should be remembered that a great deal of difficulty will be experienced in getting the chain correctly replaced if it is taken off for any purpose. Of course, where a spur gear is employed to drive the commutator, it is perfectly easy to mark one tooth and the bottom of the two opposite teeth into which it engages, thus insuring correct timing; but with a chain drive it is impossible simply to mark two teeth alone. This may be done to a certain extent with satisfaction, however, by marking the rim of the wheel on the center line; it then becomes a matter of the eye in replacing the chain, and also one of memory to insure the marks being in correct position, that is, both marks should be at the bottom or top of the wheel, as originally placed when they were indicated. One writer suggests pointers being attached to convenient parts, the marks on the chain wheel being brought opposite to these. In any case, it will, of course, be necessary to ascertain roughly the relative position of the crankshaft to the camshaft. Unless this is done, it is quite possible to get the set-



ting incorrect, as while one wheel may be in position correctly, the other may be a revolution before or behind it.

Twisting Temporary Connections.

In making a temporary electrical connection, the stranded wires should be twisted up as solid as possible, and the loop formed by turning the wire from left to right. When so made, the loop closes in under the twisting action of the screw when tightening up the connection. If the loop be made in the opposite direction, this same action spreads the wire, and a bad connection results.

Contact Breaker and Commutator.

The terms contact breaker and commutator are at present being very loosely used in connection with automobiling, simply on account of their functions not being definitely and clearly understood. To all intents and purposes, both serve the same purpose, which is that of an automatic switch completing the circuit of an electric current at a given time. The contact breaker, whether it be of the spring blade or of the wiping contact type, is used in connection with single-cylinder engines only, while the commutator is used on multi-cylinder engines, though its type and design may be precisely similar to that of the wiping contact breaker on the single-cylinder engine. The very word "commutator" should be sufficiently expressive to prevent this error, as its meaning clearly shows that its mission is to "commute," or to exchange, the current from one path to another—that is, of course, from one cylinder to another. It could only be a contact breaker when each cylinder was supplied with a separate source of electrical energy, and with a separate coil, though when the common source of supply is from a single storage battery, notwithstanding that it traverses a separate coil for each cylinder, it then becomes a commutator. See Contact Breaker and Contact Maker.

Multi-Cylinder Ignition Timing.

There are still a few makers of four-cylinder engines who adhere to make-and-break ignition contacts as their standard, and when perfectly adjusted and tuned up, this ignition is quite as satisfactory as the trembler coil and wipe contact; but when the slightest derangement occurs, the trouble is difficult to locate, and often inexplicable. Presupposing that all the platinum contacts are in good condition, and that each cylinder is firing in its turn, it is yet quite possible that anything but the best results are being obtained. The defect arises solely from faulty ignition timing, due to the fact that the points of the platinum-tipped screws and blades are not all equally adjusted. Thus, if we suppose our four tremblers to be adjusted with No. 1 set of points 1 millimeter apart, No. 2 set 1.5 mm., No. 3 set 1.4 mm., and No. 4 set 1.2 mm., the cam having a 3 mm. eccentricity, each and every trembler will give a spark at its full power; but if we suppose that trembler No. 1 is firing accurately, No. 2 is firing late, No. 3 late also but earlier than No. 2, No. 4 earlier than either No. 2 or No. 3 but later than the correct No. 1, the terms late or early being, of course, relative to the position of the piston. Thus, in each cylinder the mixture is being ignited at a different period, with the result that, if No. 1 is being fired to its best advantage, the other three cylinders are not igniting efficiently, the balance is gone, and considerable power is being lost. Beyond this, where the firing is late, the combustion is not completed until after the exhaust valves have opened; the burning charge passes out in the form of a flash, extremely detrimental to the exhaust valve heads, and tending to overheat the engine. In order that the best power may be obtained, each cylinder must explode at relatively the same point, and, therefore, when adjusting the make-and-break mechanism, great care should be taken to see that exactly the same distance separates the contact points.

On Preignition.

If preignition occurs, the engine should at once be stopped and examination be made, as it is the chief cause of bent connecting rods and broken crankshafts. The chief cause of preignition is failure of water circulation. If this should be suspected, it can be proved easily whether it is at fault by placing the hand on the radiators and water-jacket. If the former are almost cold, while the cylinder jacket is exceedingly hot, it will at once be understood that the pump is not working, or that there is an air-lock in the radiator piping. The best way to deal with the failure in either of these cases is to disconnect the outlet pipe from the pump and run the engine. If the water is not discharged, it is obvious that the pump is not working, while, on the other hand, if the water tank is filled up while the engine is running, the air-lock will probably be removed. Intermittent preignition is rather more dangerous than persistent preignition, because the latter pulls the engine up, while the former, coming at rare intervals, is far more likely to do damage owing to the driver neglecting to take precautions. A frequent cause of intermittent preignition is a short circuit in the contact breaker wire. This may be due either to the insulation of this wire becoming chafed and short circuiting to "ground," or to an errant strand at the contact breaker terminal, which frequently touches some part of the motor and "shorts."

A third cause puzzled an experienced motorist for a long time. The symptoms were of persistent preignition. The pump was suspected and overhauled. The water was emptied away and the tank refilled with cold, but before the car had traveled a hundred yards the owner was forced to stop the engine again, when, of course, he knew it was not the water circulation, but something inside the cylinder. On removing the valve caps, he found in the cylinder pieces of porcelain which had broken off the inside of a porcelain sparking plug. The central wire was held in place, and the plug was firing quite normally. These pieces of porcelain naturally got excessively hot, and caused the preignition. The owner had difficulty in getting rid of the pieces, but when removed preignition ceased.

Experiences: The Value of Diagnosis.

The foregoing hints are the result of an interesting personal experience, for faulty ignition resulted in a 16 H.P. car doing but sixteen miles an hour on the level with its levers in the

45 m.p.h. position, and reduced to a miserable crawl up anything like rising ground. The symptoms at first were precisely similar to those produced by the butterfly throttle valve having become loose on its spindle, but this was after a time proved to be an incorrect diagnosis. Next the governor was attacked, but, being found in order, the operator looked to the carbureter, rather expecting to find the gasolene supply choked to a slight extent, but everything was found clear. Between these investigations the car was run for a few miles, so that a chart of times and distances would have presented the appearance of the toothed edge of a saw. However, the operator tackled the ignition, and soon found a somewhat considerable blowing at the ignition plates (this being tested by pouring a little oil around the spindles of the tweakers) and considerable maladjustment. So much for the value of theory and diagnosis. We do not deprecate the system of observing symptoms and following them out to the end, for in a high percentage of cases the correct trouble is found, but, as we have shown, on occasions one is apt to be led far away from the actual ill. The ignition in the above case, by the way, was low-tension magneto.

Insecure Terminals.

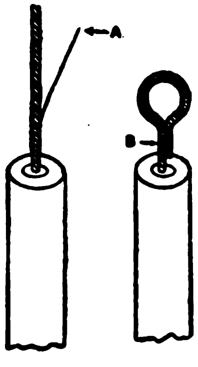
Cars are sometimes sent out with stranded connecting wires just twisted round all the terminals, and there held by the screwing up of the terminal screw. We would strongly advise any automobilist who finds his new car wired in this careless and shiftless fashion to get proper terminals soldered on without delay. It will save both time and temper in the long run. Moreover, from frequent bending round the terminals, the stranded wire breaks, and one often gets nasty, painful pricks in the fingers therefrom, which smart and are sore for some time. There can be no sort of excuse for sending out cars wired up in the slipshod way we have referred to. and the purchaser of a car should see that it is put right.

Varnish for Electric Terminals.

Electric terminals which happen to be in such a position as to be subjected to water or mud accumulating upon them can be effectually prevented from possible short circuits by painting them with a varnish composed of ordinary red sealing-wax dissolved in a little gasolene. This varnish is made by putting into a small bottle a quantity of small pieces of sealing-wax, covering the latter with spirit and occasionally shaking it. If the varnish should prove too thin, add a little more wax or leave the cork out of the bottle until some of the spirit has evaporated. If it is too thick, add sufficient spirit to bring it down to the required consistency. In order to prevent the varnish retaining the brittleness of the sealing-wax, a little linseed oil should be added. For those who do not care to go to this trouble, a little melted paraffin-wax can be used for the same purpose. The ordinary wax candle contains paraffin-wax of sufficient quality to do this. Either of these methods has been found as satisfactory as binding with insulating tape.

Making Electric Connections.

A sketch of an excellent method of making electric connections with the wire itself is given herewith. The insulation must be cut round at a convenient distance from the end, 1¼ inches to 1½ inches usually being the extreme amount required to make a connection. The stranded wires should be



twisted tightly together; one or two of the wires, according to the thickness of the strands of which the cable is composed, are taken apart, as shown by A, the cable then being retwisted. The wire should then be formed into a loop round a piece of metal or the terminal itself to a nice easy fit. The end of the wire after forming the loop should lie parallel to the wire at the beginning of the loop. The stranded wires which have been taken apart are then used to bind the end of the loop to the main body of the cable, the whole being soldered together with soft solder, which will flow easily without having to use a great deal of heat. Particular care should be taken to use resin, instead of hydrochloric acid reduced by dissolving zinc in it, or one of the many acid soldering fluids sold. The objection to using such fluids is that they set up corrosion and a chemical action at the joint, offering a high resistance to the current, and there is no doubt that the same cause is responsible for the ignition delays which some motorists experience with their cars.

Broken Plugs.

Sparking plugs with loose and leaky centers are by no means uncommon; but, treating the matter generally, very few people try to discern and remedy the cause of the trouble. More often than not the source of breakage can be traced to the festoons of heavily-insulated wire pendant from the plug terminals, or, where a neater and collective arrangement is employed, to the tighter wires from the overhead stay to the plugs which transmit the vibration to a considerable extent, resulting in a breakage. There are two methods by which this transmitted vibration can be obviated entirely, and the life of the plug increased considerably. The one is to solder a fine coil of flexible wire to the end of the high-tension cable, support the cable firmly, and connect up the remaining end of the coil to the plug terminal. In this manner the weight of the cable is taken completely from the plug, and the fine coil is quite incapable of transmitting the vibration.

A similar arrangement—one which performs the twofold functions of spark gap and non-vibrating connection—is now fitted to a number of engines. From each high-tension terminal to the plug terminal is fitted a light brass or silver chain, down which the current runs to the plug, having a minute spark gap, as a rule, between each link; but all uncovered sparking gaps are dangerous.

Spark Plug Troubles.

If the porcelain body of a sparking plug allows a loss of compression at the packing gland, it is often only necessary slightly to tighten up the hexagonal top of the circular portion of the gland. After doing so, the plug wire should be inspected to make sure that any slight rotation of the porcelain does not affect the adjustment of the two points, otherwise some misfiring or entire failure to fire the charge may result. Another frequent cause of maladjustment of these points when the plug is new is the screwing of the plug into the cylinder. When the wire attached to the metal body of the plug is hammered into position the thread is usually burred slightly. This is restored to position when the plug is screwed into the cylinder, and the wire is slightly moved in consequence. When new a plug should be filed at the thread by means of a triangular or fine half-round file, to remove the bur. The plug should be screwed home, and then removed and examined to see that the position of the wires is not varied, after which the plug can be again screwed into the cylinder, with the certainty that it will work correctly.

Warped Spark Plug Porcelain.

An Eastern motorist experienced a rather uncommon failure, accompanied by misfiring and a peculiar blowing noise in one cylinder. As the valves had recently been ground-in in all the cylinders, and no compression cocks were used, the trouble could not be located until kerosene was squirted around the valve caps and over the sparking plug. Turning the starting handle round, it was found that gas blew past the porcelain of the plug of the misfiring cylinder, though from what one could see the plug was in proper condition. On removing the plug and taking it to pieces, the porcelain was found to have warped considerably. There is no doubt that the porcelain was not true in the first place, and from some unknown cause the packing which secured it had loosened sufficiently to allow an escape of gas past it, and so caused the trouble.

A Crack in the Porcelain.

When misfiring takes place, one usually in the first instance examines the sparking plug, which is supposed to be the offender, for deposits of sooty matter or lubricating oil. In a number of cases it will be found that when the soot or oil on the porcelain has been washed off with a little gasolene, and the sparking points cleaned with fine emery or glass-paper, a very good spark is seen between the points when the metallic body of the plug is laid on the cylinder and the necessary contacts made. Yet on replacing the plug it is found that the misfiring in this particular cylinder is just as bad as ever. This is a most deceptive and annoying trouble, which will often be caused by a crack in the porcelain, either close to the wire terminal and almost imperceptible, or it may be somewhere inside the body of the plug, and therefore cannot be seen. A good spark is produced in air, but under the compression at working conditions the spark passes from the center wire through the crack in the porcelain to the metallic body of the plug, as this offers a relatively easier path than that between the points and through the compressed mixture. If the plug is held with the metal body in one hand and the porcelain in the other, and a twisting action backward and forward is applied while the plug is held close to the ear, a slight grating sound will be heard if the break is inside the body of the plug, which should be at once discarded in favor of a sound one. A new porcelain may be fitted to the defective plug if desired. Great care should be exercised in putting in or taking out plugs from the cylinder, as there is every chance that the porcelain may receive a slight tap with a spanner and be broken, porcelain being extremely brittle. This particularly applies in cases where plugs are placed in deep recesses and a box or tube spanner is required for insertion or removal. If the packing in a plug is screwed up too tightly, the heat is very likely to cause the porcelain to crack. The stuffing gland only requires tightening up to such an extent as to prevent loss of compression in working.

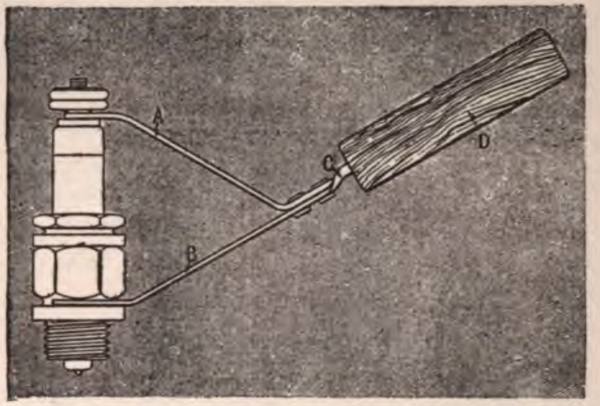
A Spark Plug Joint.

Often on the road it is found that a loss of compression is taking place past the copper washer beneath the spark plug flange, and that a spare washer is not available. An excellent substitute can be made by cutting a piece of $\frac{1}{16}$-inch copper wire the right length and bending it round circularly so that the ends overlap. Then give each of the overlapping ends a tap with a hammer to reduce the thickness to about one-half, and so that they fit together fairly. On screwing up tightly it will be found that this will make a sufficiently good temporary joint.

A Simple Spark Plug Cut-out.

The method usually employed for testing an engine—by cutting out the ignition of all the cylinders but one—is a very simple and useful one. Where a trembler coil is fitted the usual method is to hold down the tremblers of all the coils except one, allowing only one of the cylinders to work. Where a non-trembler coil is fitted it is more difficult to cut out one cylinder. For this purpose a wire has to be disconnected either from the contact breaker or the coil. The device which we illustrate herewith is one which is intended to overcome this difficulty, and may be used with any kind of sparking plug, whether operated through a non-trembler or trembler coil or magneto.

The device merely consists of a fork of some thin strip conducting material, the ends of the arms A and B of the fork being split, while the handle portion C is driven into an insulated grip D. To cut out the ignition of one cylinder this device is held up to the sparking plug of that cylinder, so that one arm touches the terminal of the sparking plug and the other either the body of the plug or any part of the engine. The current will now short circuit from the terminal through the arms A and B to ground without causing a spark at plug points. One or the other of the arms can be fitted underneath the binding screws of the sparking plug, and the device bent upward or downward, so as to bring the other arm into or out of contact with the body of the plug, and so provide a fixed cut-out, which can be used during testing somewhat after the manner of the cut-out plugs used on some magneto ignition systems. This is a little instrument which can be made by anybody and carried in a toolbox to be used when required.



On Testing Ignition Sparks.

In one of his interesting articles on electric ignition, Mr. C. E. Duryea gives a useful tip for testing either low or high tension sparks. To test the high tension spark, "pass a strip of paper between the points of the sparking plug, and the paper will be perforated by the sparks, leaving a line of minute holes. To get the actual size of the spark in the cylinder, the points should be separated a quarter of an inch or more, for it is well known that the compressed air is an insulator, and that engines which frequently miss on full charges will fire regularly when throttled, thus proving that there is a larger and better spark when there is no compression.

"To test the make-and-break low-tension spark in a similar manner, connect one wire from such a system to a piece of sheet metal on which is placed a sheet of thin paper, preferably held about 1/32 inch above the metal. Connect the other wire to a common pin, and push the latter through the paper. Then pull the pin away quickly. A large spark will follow, burning a hole through the paper, frequently an eighth of an inch in diameter. Compare the area of this hole with that of the minute perforation made by the jump spark, remembering that the make-and-break spark is also longer, and it will be seen that the volume and heat of the make-and-break spark is much larger, on which account it will fire a less perfect mixture."

Setting Up New Spark Plugs

In setting up a new sparking plug, the first thing to be seen to is that the ends of the platinum sparking points are flat and parallel. In cutting off the wire for these points a pair of cutting pliers is used, with the result that the ends are left in the shape of a broad V. Now, as the sharp edges of the V are likely to be at any angle to one another, it generally happens that the actual sparking areas are but little more than equal to the diameter of a very small pin. The natural result is that a weak spark is produced, and the novice may look for a very long time before finding the real cause of it. What is required for the highest point of efficiency is two flat surfaces parallel to and opposite one another—simple conditions, but difficult to fulfill.

A Point Position Gauge.

To attain the best conditions for the sparking plug points, it is first necessary to reduce the V points to a flat surface, and this is best done with a jeweler's or any thin flat file. Having got the points up flat and parallel, they must next be set up to their correct distance. This distance is variously given as 1 millimeter, 1/32 inch, and "the thickness of a visiting card," but the distance really depends upon the power of the coil and the resistance offered by the compression of the cylinder charge. Naturally, a powerful coil with a good voltage behind it will give a "fat" and hot spark, but this may easily be offset to a certain extent by high compression. The best practice is, then, to find by experiment the most efficient position of the points, and to have a permanent guide in the form of a gauge to set them up to. This gauge may be a piece of sheet metal, and once obtained should be religiously preserved.

Screwing in New Plugs.

Before screwing a new sparking plug into its place in the cylinder head, always file down to the thread level both in the groove and over the diameter the small hump which is usually raised by the fixing of the sparking wire to the metallic body of the plug; otherwise, although the points are correctly spaced before screwing the plug into its place, there is a tendency to alter their relative positions on screwing in, and thus to cause failure in working. Always make sure that the center wire is fixed properly, otherwise if it can be moved readily the probability is that there is a bad connection, and trouble with misfiring will follow. Before putting in a plug, if the screw thread is lubricated with graphite or blacklead, it is more easily screwed in or out.

Periodical Examination of Spark Plugs.

Because your engine starts up well first time round every day, runs well to the ear, and seems to pull all right, do not leave your sparking plugs unexamined from one month's end to the other. You will insure the extra touches of speed and power if you take these fittings out from time to time, say once a fortnight, and scrape all the hard carbon off them, cleaning them finally and nicely with a stiff toothbrush dipped in gasolene. Engines with high compression will be improved by this little attention.

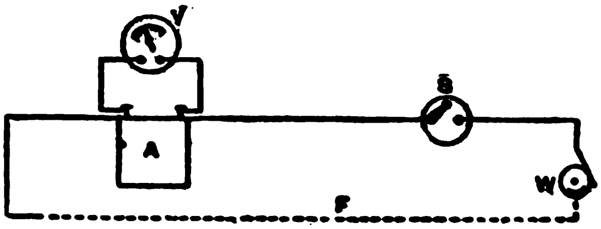
Simple Test for Short Circuits and Broken Circuits.

When troubles occur in connection with ignition, there is usually no method other than minute examination adopted for investigating the condition of the wiring in the primary circuit. Short circuits to the frame owing to chafing or cutting of insulation, and total disconnection owing to hidden breakages in the wire itself, are not unknown, so a simple means of testing for these faults may be of value. When batteries run down rapidly while at rest, the blame is put upon the cells themselves, but in reality it may be due to defective insulation of the primary circuit.

The instruments required for the test are usually ready to hand, these being simply a storage battery and a reliable voltmeter of fair size. On a peculiarity of the former the value of the test depends, for it is found that when a battery is on open circuit it gives a higher reading than when a current is flowing. The following actual readings illustrate this: Current flowing in primary circuit, 0, 1, 2, 3 amperes; readings of voltmeter, 4.05, 3.97, 3.92, 3.87 volts respectively. These readings can be taken advantage of for testing purposes as indicated below.

Short Circuit to Frame.

To test for a short circuit to the frame proceed as follows: Connect a voltmeter across the terminals of the battery (accumulator); leave the switch open, and set the wipe or contact maker so that metallic contact is not made (see sketch). Take a reading of the voltmeter. Now close the switch, watching the voltmeter carefully while this is done. If the needle moves, showing a lower reading, it conclusively shows that a current is flowing through the switch; but since there is no connection at the wipe or contact maker (contact breaker, so called), this can only be due to a leakage. If there were



A, accumulator.
F, frame wire or earth.
S, switch.
V, voltmeter.
W, wipe contact maker.

a leak between A and S, it would be detected by disconnecting the primary wire from one of the terminals of the battery; the voltmeter would then show a higher reading.

Short Circuiting at the Switch.

On one or two types of low-tension switches, the terminals to which the low-tension wires are connected are placed too near together. Consequently, if great care is not exercised when wiring up, there is always the tendency to cause a short circuit between straggling strands of the wire. In some cases, the edges of the terminal nuts are only about 1/32 inch apart, and the reader will readily see that if a loose strand is left when wiring up this might touch the other terminal and cause a short circuit. This does not matter so much when the engine is running, although, of course, the battery cannot be cut off from the contact maker, so that there is always a tendency to run the battery down when the engine is not working. A good way to decrease the risk of such a thing happening is, first of all, when wiring up, to see that no loose strands are left about. These should be nicely tucked under the terminal nuts, and after the ends are properly tightened up the whole of the nuts and the bare wire should be wrapped with insulated tape on which a thin layer of rubber solution has been pasted. A very neat job can thus be made, and one need not fear that any trouble will be experienced at this point, for the tape not only insulates the terminals, but prevents the nuts from working loose.

Broken Circuit.

To test for a broken circuit, due to breakage of a wire or bad connection at the terminals or frame, proceed as follows: Connect up the voltmeter as before, set the wipe or the contact breaker so as to make metallic connection, leave the switch open, and take the voltmeter reading. Now close the switch, and if the current flows, as it should do if the circuit is not accidentally broken somewhere, the needle of the voltmeter will move, giving a lower reading. This test may save a good deal of time spent in futile attempts to adjust contact points or tremblers. Since a strong current would pass through the coil when the points of the contact breaker or trembler are held together, as in this test, the switch should be opened again immediately the movements of the voltmeter needle have been observed.

Detecting Short Circuits.

Occasional short circuits, as a rule, give more trouble than the entire breakdown of the ignition system, because the symptoms are very much like carbureter troubles. A good and rapid way to test all parts of the ignition circuit is to run the engine in the dark, when the slightest leakage from the high-tension wires or along the porcelain of the plugs will be at once seen by the faint light which indicates the short circuit. If the high-tension insulation is carried out with a poor quality of rubber, or is too thin, "shorting" may take place at any part. The slightest film of moisture or lubricating oil on the outer part of the plug porcelain also tends to leading away the spark and cause misfiring.

Destruction of Insulation by Oil.

After a certain period of running most low-tension wires become impregnated with oil which is thrown upon them either from the crank case or from some revolving part of the engine. As is well known, oil is extremely bad for rubber insulation, and it also to some extent destroys the insulation when this is tape woven. The result is that any part of the low-tension wire which rubs on any metallic part of the frame is at some period or another just cut through slightly, or the insulation is opened so that contact of the low-tension wire is made with the frame. The result is, of course, a short circuit in the primary winding. This defect is one that is most difficult of location, because the vibration of the engine and car keeps moving the wire from contact. It would be well, in the case where insulation is found to be so impregnated with oil as to be liable to this difficulty, at once to rewire the circuit where required.

Ignition by Batteries—Causes of Failure.

Below, under the four heads of Sources of Current, Induction Coil, Wiring, and Commutator will be found nearly every cause for ignition failure, partial or entire. Although the list is somewhat awe-inspiring as to length, every source of trouble enumerated can be avoided by care and cleanliness.

Sources of Current, Storage or Dry Batteries.—Loose or dirty terminal or terminal screw. Whole or partial discharge of storage or dry battery. Internal short circuit. External short circuit. Connection between plates or elements of the battery broken. Loss of electrolyte fluid. Perforated leaky casing.

Induction Coil.—Loose or dirty terminal or terminal screw. Wire separated from terminal at inner end. Broken or fused wire in coil (rare). Faulty adjustment of trembler. Pitted or unevenly burnt platinum contacts. Insufficient insulation of terminal from which high-tension plug wire leads.

Wiring.—Bared wire. Wire insulation destroyed by oil. Wire fractured within insulation. Loose wire attachment. Terminal unscrewed or dirty. Broken earth wire. Bad or dirty contact of earth wire. Mistake in remaking connections. Poor or faulty insulation of sparking plug.

Commutator, with Trembler or Blades.—Faulty adjustment of platinum contact screws. Too far apart—misses. Too near —premature ignition. Bad or burnt-out platinum contacts. Dirty or loose unsoldered platinum contacts. Faulty insulation of platinum-pointed screw. Greasy, split or loose ignition plate. Horizontal play. Broken trembler or contact blade.

Rotary Commutator.—Contact roller arm loose on spindle. Roller worn on circumference or center. Roller spindle worn. Contact ring worn in ridges, either fiber or metal. Too little lubrication. Too much lubrication with thick grease. Carbon deposit on contacts if contact maker runs dry.

Sparking Plug.—Fouling by oil, carbonization. Fracture of porcelain insulation. Loose porcelain. Shorting through mica insulation by penetration of grease. Sparking points too remote or too near. Damp, greasy or dirty porcelain.

Loose central conductor. Bad assembly of plug. Old porcelain.

Cleaning and Adjustment of Mica Insulated Low-Tension Plugs.

On examining an igniter that has been at work for some time (two or three days' hard running), it will be sometimes found that there is a small amount of soot or carbonized oil on the mica insulations. When this is the case, the surface of the mica should be wiped, or washed with a stiff bristle brush and a little gasolene, or if in bad condition scraped till a new surface is exposed. If the micas are found to be sooty on the inside, it is evident that the motor has been running with too strong mixture, and every driver's attention should be called to it. The contact point between the wire and anvil should be kept in good condition, a file being passed between the two points should they become pitted or show much corrosion. The wire should be free in the bush between the collars, but no very perceptible longitudinal backlash should be allowed. The spark gap should be adjusted to within about the thickness of two or three igniter springs.

Ignition Adjustments, etc.

All renewals, adjustments and cleaning of igniters should be done at leisure, and the spare igniters should be kept in good condition, and should be tested in place after adjustment, so that should a change be made on the road, there is no doubt as to all being right. Should an igniter spark outside on the road to any appreciable extent, it may be set up without stopping the engine. To do this, the locking handle should be slacked off slightly and the adjustment screw turned counterclockwise until the sparking ceases. The locking handle is then tightened up again. The manufacturers recommend in general that an igniter which sparks outside should be removed and receive attention; but the above method of dealing with an igniter whose contact is worn will save time on the road. N. B.—The sparking contact must not be set too close. The points must not make permanent contact.

Ignition Adjustments—See under Ignition above.

Ignition, Advancing the—The operation of advancing the time when the spark occurs in the cylinder head. See Advance Sparking.

Ignition, Arc—See under Ignition above, also under Magneto.

Ignition by Storage or Dry Batteries, Causes of Failure—See under Ignition.

Ignition Cam—A cam which operates a contact maker or contact breaker in an ignition system.

Ignition, Care of on Tour—See under Care of a Car on Tour.

Ignition, Catalytic—See Ignition above.

Ignition, Causes of Failure—See under Ignition.

Ignition Commutator—See Commutator.

Ignition, Compression—A form of spontaneous ignition of explosive gas under high compression. Not suited to motor car work.

Ignition Conversions—See under Ignition.

Ignition, Electric—The usual form of motor-car ignition, by battery and induction coil or by magneto.

Ignition Failure, Causes of—See under Ignition.

Ignition Faults—See under Ignition.

Ignition, Flame—An early style of ignition in which a gas flame ignited the explosive charge.

Ignition Hints—See under Ignition.

Ignition, Hot-tube—A form of ignition in which the fuel charge is ignited by means of a small superheated chamber or tube secured to the interior wall of the cylinder, its heat being maintained by an external lamp.

Ignition Lamp—Same as Hot-tube Ignition.

Ignition, Jump Spark—The form of ignition in which the spark is obtained by a secondary current passing or "jumping" a gap between two points slightly separated.

Ignition, Lead of the—A term applied to ignition or sparking which occurs just before the piston has reached its maximum compression-point.

Ignition Lever—The lever by which the ignition spark may be advanced or retarded. In modern cars usually located on top of the steering wheel.

Ignition, Magneto—The ignition of the explosive charge in a motor cylinder by means of a magneto. See Ignition, also Magneto.

Ignition, Make-and-Break—The system of ignition by means of a primary electric current.

Ignition, Missing Explosions—See under Missing Explosions.

Ignition Not Sufficiently Advanced—See Causes of Overheating, under Engines.

Ignition Plug—See Spark or Sparking Plug.

Ignition Points, Synchronizing—The act of regulating the times of ignition in a multi-cylinder engine so as to secure the best results. See under Valve Setting and Ignition Timing.

Ignition, Premature—Same as Back Fire, which see. Usually shortened to Preignition.

Ignition, Self—The accidental firing of an explosive charge in a cylinder through overheating of the cylinder wall or of carbon deposits, etc.

Ignition, Slide Valve—An early form of ignition for internal combustion motors, in which a slide valve intermittently allowed a flame to ignite the charge.

Ignition Sparks, Testing—See under Ignition.

Ignition System with Plain Coil—See under Ignition.

Ignition, Testing the—See under Choice of a Car, also under Ignition.

Ignition Timing—The regulation of the time at which the spark occurs in each cylinder head. See Timing.

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walls of water jackets and in tanks of radiators and water pipes; also in steam boilers. In all these cases the incrustation is caused by foreign matter in the water used, and can be avoided by using rainwater or distilled water. The deposit of carbon in the combustion chambers of the cylinders and on the top of the piston head is another form of incrustation.

For remedies see "Water Circulation," under Repairs and Adjustments; also Overhauling.

Index—The hand, bar or needle that points to anything, as in a mechanical indicator.

Indiarubber—See Rubber.

Indiarubber Valve—See Valves.

Indiarubber Tube—See Tires.

Indicated Horse Power—See under Horse Power.

Indicator—An instrument used for taking diagrammatic records of the pressure in a cylinder at any position of the piston. The resulting diagram is used for calculating the Indicated Horse Power, which term is usually contracted to I. H. P. It is seldom used by amateurs, being intended for experimental purposes and for use in the test shop. The term is also used to describe speed indicators, which are usually affixed to the dashboard of the car. See Horse Power; Speed Indicator.

Indicator Card—The diagram made by an indicator or the card on which it is made.

Indicator Diagram—The diagram drawn by an indicator. See Indicator.

Indicator, Polarity—A device for indicating the positive and negative poles of a magnet or the polarity of an electric current.

Indicator, Speed—See Speed Indicator.

Induced Current—The term usually applied to the secondary or high-tension current. See Coil.

Inductance—The act of causing or the power to cause induction; also, in self-induction, the increase of electrical energy by induction.

Induction—The influence exerted by a body possessing electrical or magnetic properties upon a neighboring body, without apparent communication. Also applied to the introduction of the "mixture" into the combustion chamber of a gasolene motor by suction.

Induction Coil—See Coil.

Induction Coil—See under Ignition.

Induction, Electrodynamic—The generation of an electric current in a conductor by the influence of another current.

Induction, Magnetic—Magnetization induced in a magnetizable substance when brought into a magnetic field.

Induction Pipe—Same as Inlet Pipe.

Induction Port—In a steam engine, the port which is open for the admission of steam to the cylinder.

Induction, Self—Induction produced in an electric circuit by the action of the current on itself at the moment of starting or stopping, or upon a variation in its strength.

Induction Stroke—The inlet or suction stroke of the piston, which draws the charge into the combustion chamber of a gasolene engine.

Induction Valve—Same as Inlet Valve. See Valves.

Inductive Force—The force operating or created by induction.

Inductivity—Capacity for electrical induction.

Inductor—Any portion of an electrical apparatus which acts inductively upon another; also the part so acted upon.

Inertia—The property of matter by which it tends to preserve a state of rest when still and of uniform rectilinear motion when moving.

Inflating Tires—See under Tires.

Inflater—A tire pump. See Tools, Spare Parts and Accessories.

Ingate—In foundry work, the opening through which metal is poured into a mold.

Ingot—A mass or wedge of any fusible metal, cast in a mold; a mass of unwrought metal.

Ingot Iron—A term applied to decarbonized pig-iron, or Bessemer steel.

Initial Condensation—The condensation of steam which occurs by reason of its coming into contact with a cool metallic surface on entering a cylinder. It involves loss of steam and hence of power, and is minimized by heating the cylinder.

Initial Pressure—The pressure of steam or gas above atmosphere in a cylinder at the moment before it begins to develop power by explosion or expansion. The compression pressure of the combustible gas in the cylinder of an internal combustion engine must be deducted from the pressure during explosion in order to determine the expansive power of the gas, because the engine has been doing work to produce the compression pressure.

Initial Tension—The strain upon any part of a structure or mechanism which is inherent in the structure itself and not from outside.

Initial Trip, The—See under Driving.

Injection Valve—The valve in a steam engine through which cold water is admitted into the condenser to produce a vacuum.

Injector—An apparatus for supplying the boilers of steam engines, especially locomotive engines, with water. It is essentially a jet pump.

Inlet, Governing on the—See under Driving.

Inlet Cam—The cam which operates a mechanically operated inlet valve. See Internal Combustion Engine.

Inlet Pipe—The pipe by which the "mixture" travels from the carbureter to the inlet valve of a gasolene engine.

Inlet Pipe, Gauze in—See under Carbureter.

Inlet Port—The passage between the inlet pipe and the combustion chamber in which the inlet valve is situated.

Inlet Valve—The admission or induction valve by which the explosive mixture is admitted to the combustion chamber or cylinder head.

Inlet Valve—See under Internal Combustion Engine.

Inlet Valve, Repairing—See under **Makeshifts on Tour;** also Repairs and Adjustments.

Inlet Valve Cotter—See Valves.

Inlet Valve Seat—See Valves.

Inlet Valve Spring—See Valves.

Inlet Valve Stem—See Valves.

Inner Frame—A sub-frame or support inside the main frame of a motor car, for the power plant, etc.

Inner Tube—The airtight rubber tube which is placed inside the casing of a pneumatic tire.

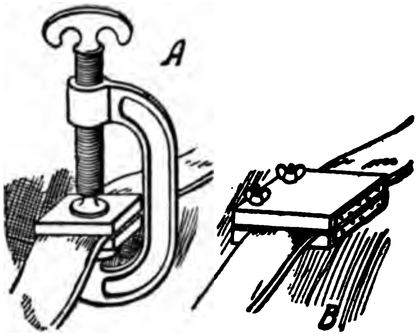
Inner Tube Accidents—See Tire Repairs.

Inner Tubes, Patching—The patching of punctured inner tubes is one of the many points involved in motor car operation and maintenance about which much is written and little understood. The average motorist, it probably can be asserted without fear of contradiction, has punctured tubes vulcanized, being driven to this rather expensive policy by a few sorry experiences with roadside repairs during his earlier acquaintance with the new conveyance. And certainly nothing could be more discouraging, on top of the lamentable enough fact of a puncture, than to have its laboriously accomplished repair give out in the first few feet of traveling. Nevertheless, it is a fact that a cemented patch can be made to hold almost as well as a vulcanized job, if a few essential things be observed in making it.

In the first place, though most instructions mention the necessity for roughing with emery cloth or by other means the surface to be joined, few of them emphasize the importance of in nowise slighting this preparatory work. But it is absolutely essential to any degree of success whatever that both surfaces be completely and thoroughly abraded, until the rubber is all roughed up by innumerable minute cuts and tears on its surface. Very coarse emery cloth, not finer than No. 3, is most suitable for the work, but finer can be used at the expense of more labor, and a coarse flat file surface is not at all bad in a pinch. Both before and after abrading, the surfaces should be thoroughly washed with a piece of waste wet with gasolene, it being particularly important to remove every trace of chalk, or talc.

When the surfaces are prepared, the cement must be applied to both of them quickly and evenly, and in quantity just great enough to insure its thorough penetration of every portion of the roughened surface. Smearing it on very quickly and with some pressure by the finger tips beats any other method that has yet been devised. A very important point is to have the treated surface on the tube larger in every direction than the size of the patch, because a loosened edge means the rapid working in of the talc from the tire, with the early ending of the patch's usefulness. After the cement is applied the surfaces must not be placed in contact until apparently nearly dry—just barely tacky. Another important point is to use patches with thick centers but thin edges. If the patches at hand are not so made, or pieces of an old tube must be used, a sharp knife will slice off the surplus thickness at the edges, if both blade and rubber are wet with water. The patches must be large enough to allow ½ to 1 inch all around the hole, according to size. Then they must be pressed and held together with considerable force—much more than the average individual is able to apply with his hands—until they firmly adhere. Overnight is not too long, and any attempt to run on the tube in less than half an hour is courting trouble. The common-sense policy is always to carry at least one reserve tube, and thus give patches a chance to dry before placing them in service.

A simple clamp of some sort is the only practical means of holding patch and tube together. The ordinary cabinetmaker's wood clamp, shown at A in the illustration, can be secured at almost any hardware store, and, used with the two thick blocks of hardwood, serves very well. A special clamp made from a hinge, two pieces of wood and a couple of bolts with wing nuts, as shown at B, is better. If nothing else is at hand, a vise is very good, wood blocks being used to protect the tube from laceration. If the surfaces between which it is clamped are such as to afford this protection, there need be no fear of tightening up on the tube too hard.—Motor Age.



Inserts, Cork—See under Cork.

Inspection of Tires—See under Tires and Wheels.

Inspection Lamp—It is unsafe to take any naked light near a gasolene motor vehicle for purposes of inspection. If an electric lamp is not available, use a Davy or safety lamp.

Inspection Pit—A framed pit in the floor of a garage or car-house by descending into which the under side of a car can be inspected or repaired. See Housing a Car and Motor House.

An inspection pit is an indispensable addition to the garage, as without it it is impossible to get at the under part of a car with any comfort. The pit should be 3 feet 6 inches in width, 4 feet 6 inches deep and 6 feet long. It should have a convenient shelf at one end for holding tools, spare parts, etc., and steps at the other end to facilitate getting up and down. A cover should be provided, fitting flush with the floor of the garage. On no account should a naked light be used, many serious accidents having occurred from this practice. If there is an electric installation, a movable electric lamp should be used, fitted with a wire protection to prevent breakage of the glass bulb. If electric light is not installed, an electric lamp lit from a battery might be used, or a form of Davy or miner's safety lamp. See Davy Lamp.

Inspection Pit Dangers—See under Motor House.

Inspection Plate—A plate by the removal of which various inclosed parts of motor car machinery can be inspected; a hand-hole plate. This is a cover bolted over an opening in the crank-case, gear-box or other case containing the mechanism. Its use enables adjustments to be made inside the box, such as tightening the bearings on the connecting-rod big ends, etc., without dismantling the box or case.

Insulated Wire—See Wires.

Insulating Tape—A tape covered with a mixture of rubber and gutta percha, and used to wrap around bare or weak places in the insulation of ignition wires. See Repairs and Adjustments.

Insulation—The placing of bodies by means of non-conductors in such a state that electricity or heat is prevented from passing. The non-conducting covering of an electric wire, etc.

Insulation, Defective—See Misfiring Through Defective Insulation, under Ignition.

Insulation, Destruction of by Oil—See under Ignition.

Insulation, Misfiring Through Defective—See under Ignition.

Insulation of Magnetos—See under Magneto.

Insulator—Any insulating agent or apparatus; a non-conductor.

Insurance—Indemnity against personal injury, loss or damage by fire, etc.; also the premium paid for such indemnity, or the amount of indemnity specified in the policy or contract.

One of the first cares of a motorist should be to adequately insure himself and his belongings against the special risks and damages which may accrue through motoring. These include not only personal injury to the owner, but damage to car through fire, explosion, self-ignition, collision or other accident; loss of car by burglary, larceny or theft; loss or damage in transit, etc. There are insurance companies which accept most of the risks arising from the modern use of the automobile, and in Europe, where employers' liability laws and other laws regarding life and property are strictly construed and enforced, insurance is carried by careful automobile owners on such risks as personal injury to third parties or claims by the public; damage to vehicles or other property belonging to third parties; employer's liability for injury to chauffeur or mechanic; mechanical breakdown, etc.

Intake—An inlet pipe.

Intake Restricted—See under Loss of Power.

Integral—Making part of a whole or necessary to make a whole. In mathematics, the function or sum of any proposed differential quantity.

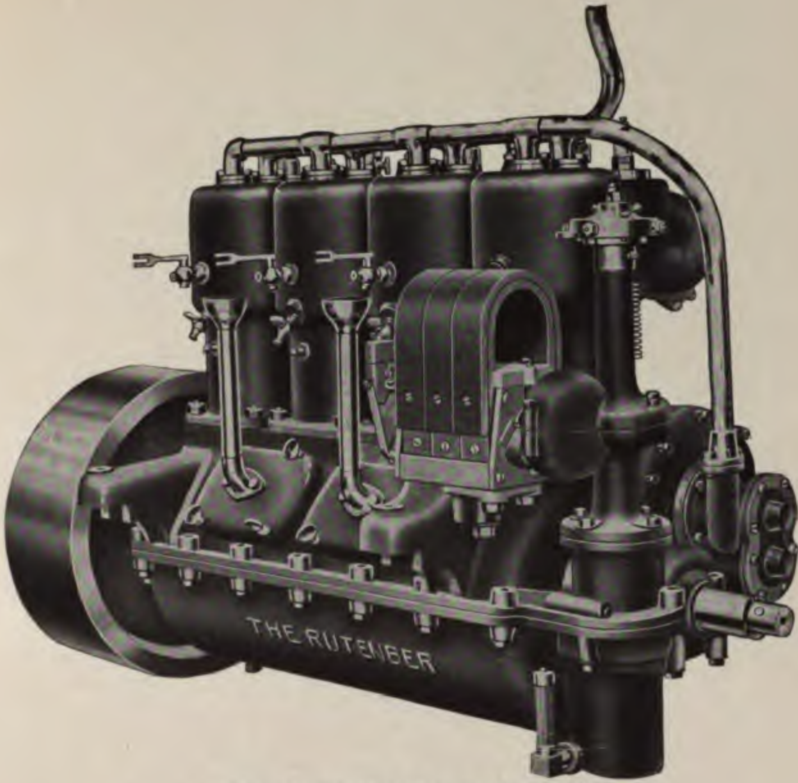
Intensifier—A device used to obtain an adjustable gap in the high-tension circuit. It consists of a glass tube with solid ends through which screw adjustable brass metal points. The gap, it is claimed, intensifies the current, so that any oil or dirt on the sparking points is burned instead of remaining to short-circuit the high-tension current. See External Spark Gap or Intensifier, under Ignition.

Intensifier, Spark—Same as Intensifier.

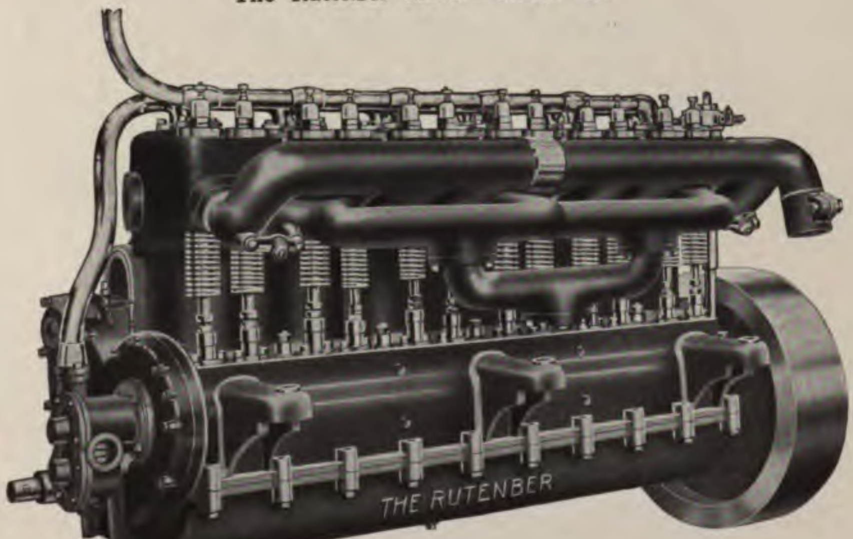
Intensity Coil—Same as Induction Coil. See Coil.

Interlock—To embrace, communicate with, or flow into one another; to interlace firmly.

Intermediate Shaft—A shaft used to carry an intermediate wheel to counteract reversal of rotation as in the case of the shaft carrying the intermediate reverse pinion. See Change Speed Gear. Any shaft carrying a wheel which gears with two other wheels on two other shafts. See Shafts.



The Rutenber Motor—Model W.



The Rutenber Six-Cylinder—Model V.

Internal Brakes—See Brakes.

Internal Clutch—See under Clutch.

Internal Combustion Engine—This is the term which perhaps best describes the gasolene engine or motor with which most automobilists have to do. The principle of operation is based on the well-known facts that gasolene vapor or a fine spray of gasolene mixed with air forms a highly inflammable mixture, and that if this mixture be confined in a closed chamber and ignited by a flame or spark it will explode and expand. This is just what is done in a gasolene engine, the expansion being utilized as the motive power.

In modern practice, the engines used for propelling automobiles are, in the majority of cases, of the internal combustion type; the notable exceptions are in the case of steam cars and electric cars, using, respectively, steam engines and electric motors. In all engines, of whatever type, providing a source of power something must be consumed. In a steam engine coal or liquid fuel is consumed in the boiler and the steam generated by the heat given off is used to produce power. The internal combustion engine is so named because the fuel used is burned or consumed inside the engine itself. It is for this reason that it forms a very simple and satisfactory way of producing power for driving a motor car. The internal combustion engine, power for power, is much lighter than any form of steam engine and boiler, besides having other very important advantages. See Electric Cars; also Steam Cars, under Motor Car.

An internal combustion engine can use various kinds of fuel, but all of them are hydrocarbons. Heavy oils are not much used in motor car practice except on heavy vehicles; and, for the sake of description, we shall take it that the internal combustion engine used in the automobile will burn the very light hydrocarbon known as gasolene or petroleum spirit. It is from this that the gas is produced which is burned inside the engine.

The production of the gas from the hydrocarbon is the function of the carbureter. (See Carbureter.) The gas, being expansive or explosive when ignited, is used to force a piston in a cylinder outward, this piston being connected by means of a connecting rod to the crank in such a manner that when it is forced out by the expansion of the gas in the cylinder it turns the crank; but the mechanism which is required to produce this apparently simple operation has other functions to perform. Before the gas can be exploded in the cylinder, it is necessary to draw it in, which means that there must be some opening in the cylinder through which it may pass. Before it can be exploded so that it will drive the piston down in the cylinder, there must be some means of closing up the entrance through which it has passed into the cylinder; while, again, before the operation of exploding the gas can be repeated, it is essential to get rid of the exhaust gases generated by the explosion. Also, some method of igniting the gas so as to cause it to expand must be provided. This latter requirement is usually attained by means of an electric spark.

Another fact to be noted is that the explosive gas drawn into the cylinder will give out greater power when ignited if it is first compressed, and therefore the engine has also to perform the function of compressing the charge. Thus the engine has four different duties to perform:

First, it has to open the inlet valve and to draw in the charge.

Second, it has to close the inlet and compress the charge.

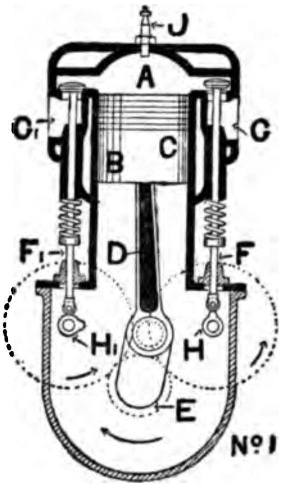
Third, it has to fire the charge so as to force the piston outward to do work.

Fourth, it has to expel the burnt gases.

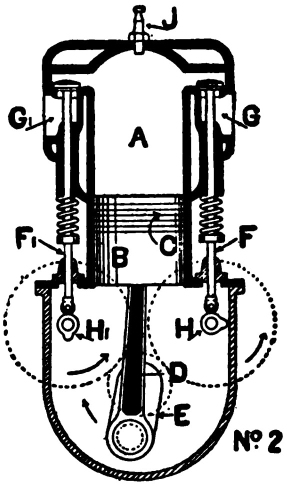
It is owing to these four operations having to be performed in sequence that the internal combustion engine, as used in automobiles, is known as a "four-cycle" engine.

In our illustrations, Figs. 1, 2, 3 and 4, we show in diagrammatic form the type of internal combustion engine usually applied to automobiles. In arrangement of details engines vary considerably, but in the main features they are all practically alike. A is the cylinder and B is the piston. This piston B is capable of sliding freely up and down inside the cylinder A, but it is provided with spring rings, which prevent any gas passing by it. D is the connecting rod which connects the piston to the crank E, which crank forms part of the engine shaft, and it is by the rotation of this that the car is driven. The piston B, when it is forced down in the cylinder, pushes round the crank E, and so turns the shaft. F and F1 are, respectively, the inlet and exhaust valves.

The gas from the carbureter enters at G, and, after having been ignited, is expelled through the port G1. The valves F and F1 are operated by the engine itself by means of cams H and H1. These cams are carried on shafts which are driven by the engine crank shaft, but at half its speed. The dotted lines indicate the gear wheels on the two shafts and on the engine, by means of which the shafts are rotated. It will be seen that the cam on either of these shafts will lift its valve once in every two revolutions of the crank shaft.

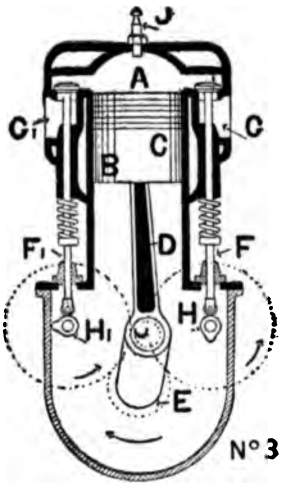


SUCTION STROKE.

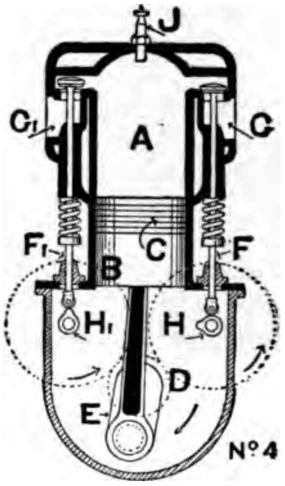


COMPRESSION STROKE.

In Fig. 1 we see that the cam has lifted the inlet valve F. At the same time the crank is in such a position that the piston is just descending in the cylinder. As the piston descends it acts as a suction pump, and draws in the gas from the carbureter through the valve port G. As soon as the piston has reached the bottom of its stroke the cam H allows the valve F to fall on its seat. The flywheel on the crank shaft of the engine, however, through its stored momentum, continues to rotate the crank, and therefore the piston B is pushed back again into the cylinder (Fig. 2), but as now there is no exit from the cylinder, the gas inside it is compressed into the combustion space. This compression proceeds until the piston has reached the top of its stroke, and at this point a spark is caused to pass across the points of the sparking plug J. As soon as this occurs, the gas charge is ignited and expands very rapidly, this expansion forcing the piston B down in the cylinder, and, through the medium of the connecting rod, turning the crank E. This is the power stroke (Fig. 3).



POWER STROKE.



EXHAUST STROKE.

Immediately before the piston reaches the bottom of its stroke, the cam H1 lifts the exhaust valve F1, the inlet valve F, of course, remaining closed. The momentum of the flywheel carries the crank round and forces the piston back up the cylinder, it in turn forcing the exhaust gases out through the exhaust port G1. This is the exhaust stroke (Fig. 4). The engine is now in a position to perform the same cycle of operations as before, the next stroke drawing the piston down and bringing in a fresh charge through the inlet G, which in turn is compressed, ignited and expelled as before. It will thus be seen that the engine during two revolutions has performed the four operations which are necessary to its proper working. The operations in sequence are as follows:

1. Down Stroke of the Piston.—Gas charge is drawn in.
2. Up Stroke of the Piston.—Gas charge is compressed.
3. Down Stroke of the Piston.—Gas charge, being ignited, is violently expanding.
4. Up Stroke of the Piston.—The exhaust gases are being expelled.

These four strokes of the piston, respectively, are known as the Suction, Compression, Power and Exhaust strokes, as indicated under the diagrams.

As the initial operation is to draw in a charge of gas, it will be seen that before the engine can be started it is necessary to rotate the crank shaft so that a charge is drawn in and compressed. This is then fired, and the engine will continue to operate automatically.

The action of the engine being understood from the study of the diagrams, we may now describe a typical automobile engine. The engine may have one or more cylinders. Four is, however, a general number, and the engine which we shall describe is a four-cylindered one. Our illustration is of a four-cylinder 35 H.P. engine. Fig. 5 shows it in cross-section through one cylinder; that is to say, the engine is shown cut in half through the cylinder and valve chests and through the crank case. Here we have again what was described in diagrammatic form in Figs. 1 to 4, but this is the actual arrangement of an efficient and modern automobile engine. Fig. 6 illustrates the same engine in section longitudinally, showing all four cylinders, crank shaft and flywheel. In both these diagrams we shall retain the same letters for the different parts as shown in diagrams Figs. 1 to 4. A is the cylinder; B is the piston with its rings C; D is the connecting rod, and E is the crank. The rings C around the piston are made of spring cast-iron, and by their own springiness they hold tightly up

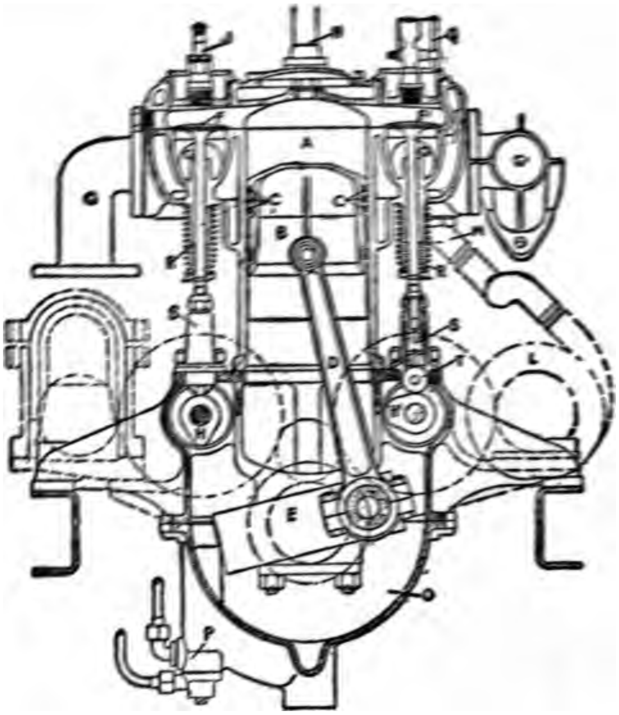


FIG. 5—CROSS SECTION OF A 35 H. P. ENGINE.

Index to Figs. 5, 6 and 7.

A, Cylinder.
B, Piston.
C, Piston rings.
D, Connecting rod.
E, Crank.
E_1, E_1, E_1, E_1, Crank pins.
E_2, E_2, E_2, E_2, Radial oil leads on big end bearings.
E_3, E_3, E_3, E_3, Holes for ejecting oil from big end bearings.
F, Inlet valve.
F_1, Exhaust valve.
G, Inlet port.
G_1, Exhaust port.
H, Inlet cam.
H_1, Exhaust cam.
H_2, Oil pump cam.
H_3, Oil pump plunger.
H_4, Spring keeping oil pump plunger in contact with cam H_2.
H_5, Automatic delivery valve to oil pump.
J, Sparking plug.
K, Water jacket.
L, Water pump (in dotted lines).
M, Water inlet.
N, Water outlet.
O, Crank case.
P, Oil pump.
Q, Compression tap.
R, R, Valve springs.
S, Valve plunger.
T, Roller on valve plunger.
U, Crank shaft.
V, V, V, Crank shaft main bearings.
W, Fly-wheel.
W_1, Coupling on fly-wheel to crank shaft.
X, X, X, Oil leads to main bearings.
X_1, X_1, X_1, Radial holes leading from main bearings to crank shaft centre.
Y and Y, Ball thrust bearings on forward main bearing to crank shaft.
Z, Pinion wheel on crank shaft.
Z_1, Intermediate pinion.
Z_2, One of the two gear wheels meshing with intermediate pinion Z_1, and driving the inlet and exhaust cam shafts.
Z_3, Oil sump from which oil is drawn to the pump.

against the wall of the cylinder in such a way as to prevent the passage of any gas.

An illustration of a piston is shown at Fig. 5A, though this is not the piston of the engine we are describing. It will be seen that there are three rings in grooves. These rings are slotted, as shown, diagonally. The diagonal slot in the center ring is not shown in our illustration, as it is behind the piston. The rings are normally bigger than the inside of the cylinder, but when contracted so that the diagonal slots are closed up, they will fit inside the cylinder, and will keep tight against it owing to their tendency to spring outward. These slots in the piston are kept an equal distance apart so as to preclude the passage of gas.

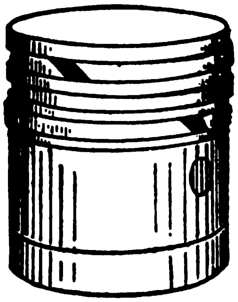


FIG. 5A—PISTON WITH RINGS.

Returning to Fig. 5, F is the inlet valve and F1 the exhaust valve, while G and G1 are, respectively, the inlet and exhaust ports. H is the inlet valve cam, and H1 is the exhaust valve cam. These are on shafts which are driven by gear wheels from the engine, indicated by the dotted lines, but shown in position at Z, Z1 and Z2 in Fig. 6. J is the sparking plug. It will be seen that around the cylinder and around the valves there is a pocket or jacket K (Fig. 6). This jacket is used for keeping the cylinders at a temperature at which the engine will work efficiently, and water is circulated through the jacket from a pump, shown in outline at L, which forces water up through the pipe M and out at the top of the jacket through the pipe N. One jacket is used for one pair of cylinders, and another jacket for the other pair, as is shown quite clearly in Fig. 6.

The crank shaft of the engine is carried in bearings which are fixed in the crank case O. This case is made of aluminum, and not only incloses the engine, cam shafts and gearing, but is also used to assist in the lubrication, which is a most important feature of all internal combustion engines. For this purpose there is an oil pump P driven by the engine, and shown in Fig. 7, to which we shall shortly refer. This pumps oil out of the bottom of the crank case O, and forces it to the various bearings of the engine. At Q is shown a valve, tap or cock, known as the compression cock. By opening this, kerosene can be injected into the cylinder for the purpose of facilitating starting, and at the same time the compression will be released, as, while this is open, the rising piston will force the gas or air out through this valve. It will be seen that the valves, both inlet and exhaust, are kept down on their seats by means of springs R, R. The cams lift them through the medium of plungers S, S, these plungers being arranged with an adjustable screw by means of which the lift of the valves may be regulated. At their ends they carry rollers, one of which is shown at T, and it is against these rollers that the cams work.

Referring now to Fig. 6, which shows the same engine in section longitudinally, we can see the arrangement of the cranks, connecting rods and the gear which drives the two cam shafts—one at either side of the engine. (Here, again, the same reference letters are used to denote similar parts to those in Fig. 5.) In this illustration it can be seen that the two cylinders of each pair are cast in one piece, with one water jacket K surrounding them. This view, of course, does not show the valve chambers, as these are on each side of the cylinders.

Shaft U, as will be seen, runs through three main bearings, V, V, V. These bearings are of special anti-friction metal. At the end of the crank shaft is the flywheel W, which is attached to the crank shaft by means of the flange, formed in

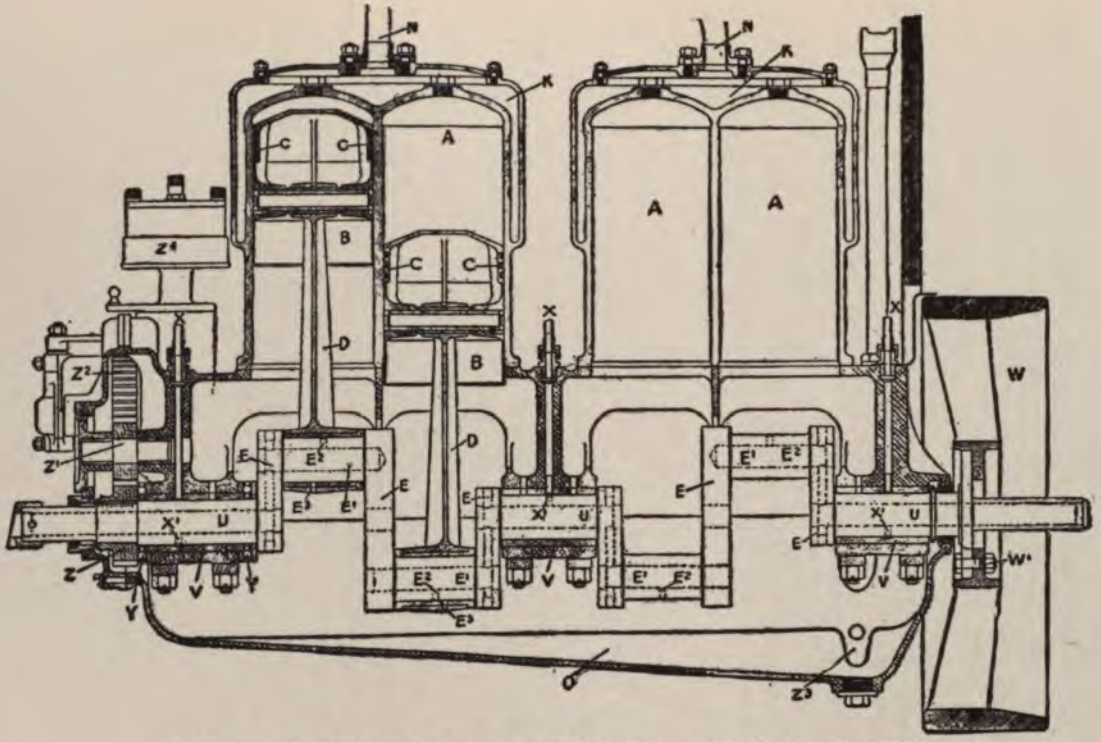


FIG. 6—LONGITUDINAL SECTION OF A 35 H. P. ENGINE.

one with the crank shaft, and the bolts and nuts, one pair of which is shown at W1.

The main bearings are carried in brackets which are suspended from the top of the crank case, and in order to lubricate these there are oil leads X, X, X. These oil leads are connected to the pump (which is illustrated at P in Fig. 5).

In order to take up any end-thrust on the crank shaft when the clutch is released, there are ball-thrust bearings shown at Y just behind the forward main bearing of the engine, and in front of this bearing.

Two connecting rods D, D, from each pair of cylinders, drive on two crank pins between the center and forward bearings, and similarly between the center and after-bearing—this arrangement allowing a very wide bearing to the crank pins.

At Z is shown the pinion wheel which is attached to the end of the crank shaft U. This pinion wheel drives the intermediate pinion Z1, which, in turn, is in gear with two larger gear wheels, one of which is shown at Z2. One of these gear wheels is attached to the inlet valve cam shaft, and the other to the exhaust valve cam shaft.

At Z3 is shown the lowest part of the crank case. It is from this that the oil pump forces up the oil to the different bearings of the engine, the oil naturally gravitating to this end of the crank case.

From this illustration (Fig. 6) will also be seen what is practically the up-to-date practice as regards lubrication. We have seen how the pump lifts the oil from the crank case and carries it to the different bearings of the engine under pressure. The oil enters these bearings by means of the oil pipes or leads X, X, X, and runs down to the main bearings of the crank shaft. Each of these main bearings to the crank shaft is provided with a recessed groove, which comes opposite the end of the oil lead X. The crank shaft itself is hollow, and a radial hole is drilled through the crank shaft into the hollow portion, so as to come opposite the groove in the main bearings. These radial holes are shown at X1, X1, X1.

The oil fed to the bearings is forced through these holes into the central hollow part of the crank shaft, and it then runs up the crank webs E, E, E, E, E, E through holes shown in dotted lines through the center of the crank pins. The crank pins, the crank webs and the crank shaft form one solid piece.

The crank pins are shown at E1, E1, E1 and E1. It will be seen that radial holes E2, E2, E2, E2 supply the lubricant to the big-end bearings of the connecting rod D, the surplus oil being ejected through a hole in the brasses and connecting rod ends, one of which is shown at E3.

At Z4 is shown a case containing a contact maker and high-tension distributer. These are arranged on the top of a vertical shaft driven by skew gear from the inlet cam shaft.

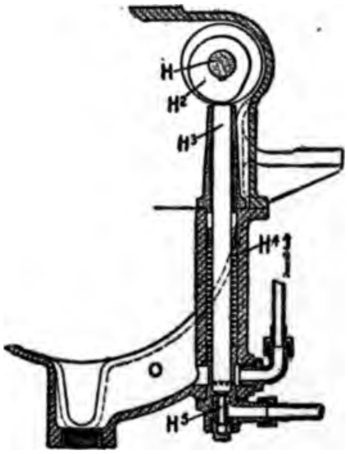


FIG. 7.

FIG. 7—CAM DRIVEN PLUNGER PUMP OF 35 H. P. ENGINE.

In Fig. 7 is an illustration of the oil pump which is arranged inside the crank case O. This pump is driven from the inlet cam shaft H, which, for this purpose, carries another cam H2. This cam comes in contact with the top of the pump plunger H3, which is kept normally pressed up against the cam by the spring H4. At its bottom end this pump plunger, where it enters the pump chamber, has radial holes around it.

As it rises it draws in the oil lying in the bottom of the crank case, and in its descent, by means of the cam, it forces the oil through the delivery valve H5 to the engine.

We have purposely chosen, for illustrating the arrangement of the internal combustion engine, an engine of late design, and one which is fitted to a car which has proved its efficiency. It must be understood, however, that the arrangement of the valves and the cam shafts is not arbitrary, neither is the arrangement of the cylinders in pairs, with water jackets round each pair, exclusively adopted. Some manufacturers arrange the cylinders separately, each with its own water jacket; others cast all four cylinders "en bloc." Then, again, many makers have all valves, both inlet and exhaust, arranged on one side of the engine instead of on opposite sides, as in the case we have illustrated. In this case, of course, only one cam shaft is required.

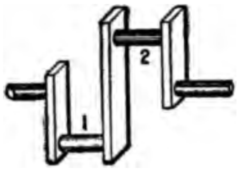


FIG. 8.—TWO-CYLINDER ENGINE WITH CRANKS SET AT 180 DEGS.

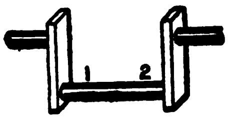


FIG. 9.—TWO-CYLINDER ENGINE WITH CRANKS SET TOGETHER.

As regards the arrangement of the crank shaft, in this there is also a diversity in current practice. In our illustration of the 35 H.P. engine it will be seen that the two pistons nearest the central bearing are descending at the same time, while the two pistons nearest the extreme outside bearings are ascending at the same time. This arrangement may be varied in the case of four-cylindered engines, but is generally the same as in the system illustrated. In some engines the crank shaft bearings are arranged between each crank pin, and some engines have ball-bearing crank shafts. The firing sequence of cylinders in multi-cylindered engines also varies according to the individual ideas of the manufacturer.

The sequence of the firing strokes depends to a certain extent upon the angle at which the cranks on the crank shaft are set. This angle may be either 180, or the cranks may be set together. Where the cranks in a two-cylinder engine are set at 180 degrees (Fig. 8), the two cylinders fire immediately one after another, so that during one revolution there are two impulses, and at the next no impulse. If the cranks are set together (Fig. 9) an impulse occurs at every revolution, but in this case the cranks must be balanced to counteract the vibration set up by all the parts moving in the same direction at the same time.

The following is the sequence in a two-cylinder engine, when the cranks are set at 180 degrees:

First Cylinder.	Second Cylinder.
Suction.	Exhaust.
Compression.	Suction.
Firing.	Compression.
Exhaust.	Firing.

When the cranks are set together, the following is the sequence:

First Cylinder.	Second Cylinder.
Suction.	Firing.
Compression.	Exhaust.
Firing.	Suction.
Exhaust.	Compression.

In the four-cylinder engine the cranks are set at an angle of 180 degrees to each other in the relative positions shown in Fig. 10. This arrangement is such that two impulses are obtained for each revolution of the crank shaft, while the disposition of the cranks is considered to give the best balance in the running of the engine. The firing sequence is—1, 2, 4, 3.

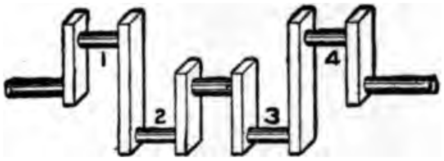


FIG. 10.—FOUR-CYLINDER ENGINE WITH CRANKS SET AT 180 DEGREES.

In the six-cylinder engine the cranks are set at an angle of 120 degrees to each other, the two center crank pins being in line with one another. The opinion of engineers differs widely as to the best firing sequence, as there are a number of different possible combinations. For instance, the combination 1, 4, 2, 6, 3, 5 is used on the Napier cars, while 1, 5, 3, 6, 2, 4 is occasionally used, but is not by any means definitely accepted as the correct one.

Eight-cylinder engines are still very much in the minority. Usually the engines are of the V type, with four cylinders at either side of the crank shaft.

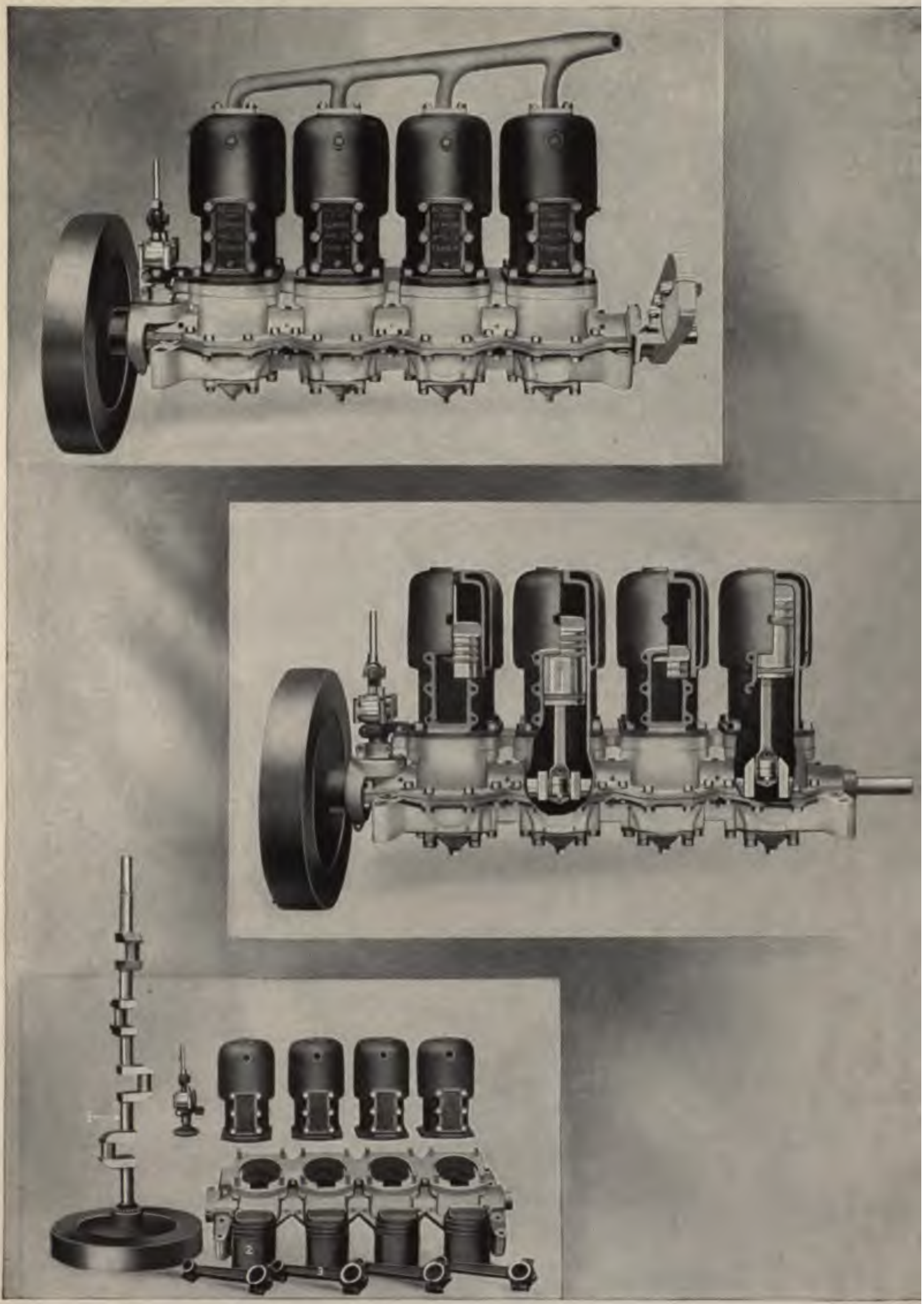
In order to grasp how the engine transmits the power to the road wheels, the articles under Motor Car and Transmission (under Change Speed Gear) should be carefully studied.

We should also advise the beginner to make himself thoroughly acquainted with the principles of the design and construction of the various vital parts of the engine and the variations in different systems, and with this object in view he should peruse the articles on Carbureter, Ignition, Contact Maker, Distributer, Sparking Plug, Valves, Cooling, Clutch, Flywheel, Cam, Cam Shaft, Piston, etc.

The Two-stroke Engine.

We may here refer to the two-stroke engine of the internal combustion type in which there is an explosion at every revolution of the crank shaft. In this type of engine the cylinder is not utilized for the purpose of compressing the charge, although the piston is. The crank case acts as a supplementary air chamber into which the gas to be exploded can be drawn and then forced into the cylinder under pressure. The incoming gas charge forces the exhaust gases out.

A diagrammatic view of a simple arrangement of the two-cycle engine, which, however, is made in a variety of different types, is shown in Fig. 11. A is the cylinder and B is the piston, D being the connecting rod and E the crank. The crank case O is made as air-tight as possible, and an automatic inlet valve F is arranged so as to admit the gas to the



The Elmore Valveless Two-Cycle Engine, Complete, in Section, and Taken Apart.
Parts indicated by numbers 1, 2, 3, are the only moving parts.

crank chamber. There is a pipe leading from the crank chamber to the inside of the cylinder A, this pipe being shown at G. When the piston is at the bottom of its stroke it uncovers the top of the pipe G, so that the cylinder A comes into communication with the crank case O.

P is the exhaust port, which is uncovered by the piston when it reaches the bottom of its stroke. Q is a baffle plate, which, when the piston has opened the top of the pipe G, comes opposite to that opening and directs the incoming gas charge in an upward direction. The cycle of operations is as follows:

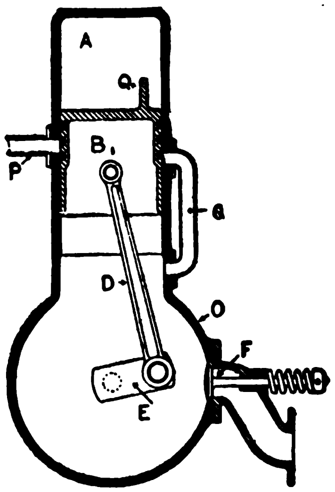


FIG. 11.—A TWO-CYCLE ENGINE.

The first up stroke of the piston draws the charge of gas into the crank case through the valve F. The piston then descends, compressing the gas charge in the crank case. When it reaches that point at which the top of the pipe G is uncovered, the compressed gases in the crank case rush through pipe G into the cylinder A. The piston then ascends, and when it reaches the top of its stroke the charge is fired and the piston descends until it reaches that point at which the exhaust port P is uncovered. This is the power stroke, and during this power stroke another charge of gas, which came into the crank chamber owing to the upward suction of the piston, is being compressed, and just after the exhaust P is opened this compressed charge rushes up through pipe G into cylinder A; the returning piston further compresses it there, and when it is at the top the charge is fired. The incoming charge during the time that the piston B has uncovered both the exhaust port P and the top of G violently pushes the exhaust gases out through P. By this arrangement an impulse is given to the piston on each revolution, so that there is no need for any mechanically operated valve, the only valve being the automatic one at F. Such engines, though not largely used for motor vehicle purposes, are very popular for motor boats, and, in fact, for this purpose have proved themselves to be among the most efficient of internal combustion engines.

ANOTHER VIEW OF THE MOTOR.

There is no magic about a gasolene motor, writes an eminent authority on motoring; it is just a particular kind of gas engine. Gasolene is a petroleum spirit of a certain chemical denomination—one of the hydrocarbons. Coal gas or ordinary illuminating gas is another of the hydrocarbons. Gasolene is a highly volatile spirit, and when its vapor is diluted with a certain proportion of air, it will "combust" with extreme rapidity; in the same way as when the air in a room becomes charged with a certain proportion of coal gas, owing to an escape, the introduction of a naked flame into that room causes an explosion. A motor means that which moves, and an engine means an ingenious machine, generally a motor. It is more usual to speak of a gasolene "motor" and a steam "engine," but the motor and engine are practically alternatives in automobile parlance. So gasolene motor, hydrocarbon motor, explosion motor and internal combustion motor are more or less equivalents, though one would not speak of a motor using alcohol fuel as a gasolene motor, of course, though operating on the same principle. "Internal combustion motor" implies that the fuel is burned in the motor, instead of outside the same in the fire box or furnace of a boiler, as in a steam engine. The apparatus by which the gasolene vapor and air are mixed together is called a carbureter, or carburator, from the fact that by it the air is charged with the hydrocarbon. At the beginning it is enough to know that the gas or mixture is sucked from the carbureter into the engine by the action of the latter.

The Elements of the Motor.

The engine or motor consists primarily of a cylinder, a piston, a crankshaft, and a rod connecting the piston to the crank on the shaft. The cylinder is, of course, hollow and open at one end. The piston slides up and down in the cylinder as the plunger of a tire-pump slides up and down in its barrel. The piston operates on the crank through the connecting rod, pretty much as the cyclist turns the crank of his bicycle by his leg from the knee.

The operation of the gasolene motor differs from that of the cyclist in that, while with the latter an impulse is communicated to the crankshaft at every half revolution, in a single-cylinder gasolene motor there is only one impulse for every other or alternate revolution of the crankshaft.

The motor has a cycle or series of four operations: 1, suction (intake or induction); 2, compression; 3, firing (ignition, combustion, or explosion); and 4, exhaust. They are performed in two revolutions of the crankshaft, corresponding to two outward or downward strokes and two return or upward strokes of the piston.

1, Suction. Suppose the exhaust gases of one charge have just been disposed of, the momentum imparted by the last explosion to the crankshaft (and stored up in the flywheel fixed thereto) causes the crank to descend and to draw down the piston by the connecting rod. As the piston descends, it tends to create a vacuum in the cylinder head, which is called the combustion chamber. The inlet valve opens, either by reason of the suction, or by mechanical means to be explained later. In either case, as the valve opens, the combustible gas is drawn into the cylinder head through the inlet valve. As the piston approaches the end of its downward stroke, the valve is closed by a spring, and the gas is imprisoned in the combustion chamber. But it is no use firing it yet, because it could not drive the piston any further if we did, so we must let the piston return to its other extreme position near the top of the cylinder. We must not fire it before it gets to the top, else we shall make the piston return too soon and drive the crankshaft round in the reverse direction.

2, Compression—As the piston rises (still driven by the momentum), it compresses the gas. This compressing action makes great demands on the momentum, but it is more than worth it, because the subsequent impulse is very much more powerful than it would be if the gas were not compressed.

3, Firing—When the piston has got back to the top of its stroke, the compressed gas is fired by an electric spark. The consequent combustion or explosion deals a blow at the top of the piston which drives it down the cylinder with great force. When the piston has nearly got to the bottom of this stroke, an exhaust valve is opened mechanically, and the hot waste burned gases begin to rush past it and out through a port to the muffler.

4, Exhaust—As the piston rises for the second time, it sweeps out nearly all the remaining waste gases, and leaves the motor ready to receive the next charge of mixture.

And so on again and again, the whole series being repeated about two hundred to two hundred and fifty times a minute on the average—five hundred times or more in some motorcycle engines.

The Gasolene Fuel.

Now let us look at these matters more in detail. First as to gasolene. This name applies to a spirit weighing about sixty-eight per cent. as much as water—not quite 7 lbs. to the gallon at 60° F. But the name gasolene covers lower qualities of spirit of as high as .76° specific gravity.

In pouring the gasolene into the tank, a perfectly clean funnel with a very fine gauze strainer should be used, as any solid particles admitted are likely to choke the jet of the carbureter. If the gasolene be poured through a piece of fine cambric laid over and depressed into the top of the funnel, the passage of water will be resisted. Wipe the top of the can clean before opening it. Often the orifice of the can is covered by a screw cap having slots or notches in the top. Such a cap can be turned by the edge of the bottom of another can or by a thin tire lever, or even the edge of the car step—inserted in the notches. The spout of the funnel should not fit the hole in the tank tightly, or the air will not pass freely out of the tank. Some spouts have air-grooves—others may be squeezed slightly to destroy their circular form.

Some Necessary Precautions.

The regulations respecting gasolene should be strictly observed; and the fact that gasolene is about to be kept on the premises—if the case—should be known to your fire insurance company.

The gasolene tank on the car is sometimes set sufficiently high to allow the liquid to gravitate into the carbureter. Where this is not the case, the fuel is forced out of the tank by pressure, obtained from the exhaust of the motor, etc.

Gasolene, though not explosive in its liquid form, is highly inflammable, and no naked light should ever be brought near it. A lighted match idly thrown down has accounted for the destruction of a number of cars. Any leakage in the tank, the carbureter, or the connecting pipe should be immediately repaired—the gasolene having been previously run off and time given for the vapor to thoroughly disperse. Should any gasolene catch light, use one of the special gasolene extinguishers; or failing that, throw sand on at once, or salt, or even flour—anything that will exclude the air. Water is worse than useless, as it only spreads the burning spirit about. Of course, if the fire occurs near or under the car, move the latter away at once.

The Carbureter.

The carbureter may act on any one of three different principles, and be distinguished as a surface, wick, or spray carbureter, accordingly. See Carbureter.

The type almost universal on automobiles is the spray carbureter. In this, the gasolene is drawn through a nozzle or jet by the engine, and as it leaves the jet in the form of spray, it mixes with air which is sucked into the carbureter at the same time. Now, as the air must be charged with a certain proportion of gasolene vapor in order to obtain the best results, it will be apparent that the form and dimensions of the carbureter must be carefully designed, and that the flow of gasolene must be properly regulated. To accomplish the second object, a float valve is employed. Instead of being led directly to the nozzle the gasolene is fed through a pipe into a chamber in which is a float, nearly filling the same. In some carbureters the floats are principally made of cork, but they are generally constructed of thin metal. Pivoted to the top or bottom of the chamber of a typical carbureter are two weighted levers. The outer ends of these levers bear against the float; the inner ends engage in a grooved collar fixed to a wire or needle. This needle has a conical point adapted to fit into a corresponding conical seating at the point where the gasolene enters the chamber. As the gasolene gets deeper in the chamber it raises the float, the outer ends of the levers rise, the inner ends are forced down, and the pointed end of the needle is thrust farther and farther into the seating, so that when the gasolene has reached the desired height in the chamber the supply is cut off. There is a small passage communicating between the float chamber and the nozzle, consequently the gasolene will stand at the same height in the nozzle as in the chamber. Usually the float valve device is arranged to keep the gasolene at about one-sixteenth inch below the level of the top of the jet. This is all very well while the car is on the horizontal, but it will not answer properly on steep hills if the float chamber is arranged behind or in front of the nozzle. Cars sometimes stop on stiff gradients because the gasolene does not rise high enough in the nozzle. When the float chamber is set at one side of the nozzle the difficulty arises that if the car is standing on the side of a heavily-arched or cambered road the level will be upset; and this, if it does not stop a motor that is already running, may make it very difficult to restart, if once stopped. In such a case the car should be moved off the slope, so as to restore the level. In some carbureters this trouble is not so liable to arise, as the float and nozzle are arranged concentrically. In actual running the needle valve practically never closes, but keeps at such a position that it lets through just sufficient gasolene to maintain the proper level in the carbureter.

Carbureter Adjustments.

The air to be carbureted is let in through the bottom or side of the jet chamber, and passes up outside the jet to the inlet valve of the motor. Generally, the air so admitted is purposely overcharged, and the correct mixture is obtained by letting in more air through apertures located somewhere between the jet and the inlet valve of the motor. These apertures can be opened and closed more or less until the desired mixture is obtained. In dry, warm weather the additional air inlets may be opened, perhaps to their fullest extent; in damp, cold weather they may have to be closed entirely. It is desirable that this regulation should be within the control of the driver while traveling, but too often this is not the case. Sometimes, indeed, the maker adjusts the carbureter (presumably to suit the most unfavorable atmospheric conditions), and the user is given no control over it. An attempt is made to imitate the best state of the atmosphere by taking the main air supply from round the exhaust pipe or some other warm neighborhood; or the jet chamber has double walls, and part of the hot exhaust gases or some of the heated "cooling" water is led in between them. Both these devices are useful in, say, foggy or drizzly weather, but they should be quite optional, as a warm charge of mixture is less dense than a cold one, and to get the most out of the engine it is essential that it should take in as large (or dense) a charge as possible. The carburation should be fully adaptable to the prevailing conditions.

A filter should be introduced into the pipe leading from the gasolene tank to the carbureter. This will serve to catch solid particles which might otherwise be carried up into the jet and obstruct it. There should also be a little well with a screw cap directly below the jet; besides acting as a settling chamber, the screw cap allows for clearing the jet—if of the single orifice type—by thrusting up a piece of fine, soft wire. Another detail consists of an inverted cone or some other form of baffle arranged over the jet. The object of this is to break up the spray of gasolene as it strikes it, and so help to vaporize the fuel. Before starting, the combustion spaces of the motor may be full of practically pure air, and the gasolene standing in the carbureter is probably stale. See Gasolene, Stale. Hence a heavily charged mixture is required to obtain an explosion. This may be obtained by causing the gasolene to overflow the jet of the carbureter. For this purpose the needle valve in the float chamber must be held open, either by holding up the needle, if it projects through the top, or by pushing down the float by means of a little plunger provided on the top of the float feed chamber.

Proportioning the Mixture.

It will be easily believed that motors of different sizes require carbureters of different sizes, and that a variation in speed of the motor calls for a variation in the dimensions of the orifices admitting air and gasolene. Most carbureters are made in a number of different sizes, and many are made with both interchangeable jets having different numbers of outlets, and interchangeable "choke tubes" or "strangling tubes," or linings of different diameters for the jet space. By these means the flow of gasolene and volume of air can be regulated to suit any particular engine. Some carbureters have, in addition to or instead of the above adjustments, automatic regulating devices designed to maintain the proper proportions of air and gasolene. Variation in speed of the engine tends to upset it by taking overdoses of the spirit when going fast or racing, and the reverse when going slowly. The arrangement generally consists of an extra air inlet, normally closed by a spring, but adapted to open proportionately as the suction effect increases with the speed of the engine.

Every carbureter should be fitted with a throttle, that is, a door or valve, by which the quantity of mixture passing to the engine may be regulated. The throttle may be automatically controlled by a governor, and it should be arbitrarily controllable by the driver; the construction being such that the automatic control is subject to the arbitrary or positive. But many modern cars are built without governors.

From the carbureter the mixture passes to the engine through an inlet pipe. This pipe should not be too long—preferably not over 15 inches. Where there are two or more cylinders, the inlet pipe will have to be divided into branches, and these should be so designed that the lengths of the passages to be traversed by the mixture on its way to the respective cylinders are all equal. Simple and speedy means for disconnecting the inlet pipe should be provided at all its terminals. The connections should be gas-tight, otherwise carburation will be interfered with, and unequal results obtained from the different cylinders.

The Engine Proper.

Now we come to the motor itself. The first question to be decided is the number of cylinders. A single-cylinder is naturally the simplest, and, by some, considered most suitable to the novice. It has the disadvantage of being uncomfortable, its intermittent action in many cases setting up a considerable amount of vibration. This defect can be considerably modified by having a large diameter and heavy-rimmed flywheel, but it is much better met by adding to the number of cylinders, so that, for the same power, the impulses may be reduced in force, and increased in frequency. Even the novice is sometimes better off with a multi-cylinder engine, as if a defect in one cylinder baffles him, he still has one or more left to take him home. The smoother running is, of course, better for the car as well as for the occupants. In the two-cylinder motor the impulses may be timed to occur either at equal intervals, that is, at every two strokes of the piston and one turn of the crankshaft; or one at a half-turn of the shaft after the other, that is, at intervals of one stroke and three strokes. The former arrangement has the advantage that the "torque," or turning force, of the crankshaft is more regular, while with the latter the reciprocating parts are better balanced. With three, four, or six cylinders, these two advantages may be combined, but the complication, weight, and cost are all added to.

Position of Cylinders and Crankshafts.

Two other general considerations respecting the motor call for decision by a prospective purchaser. One is as to whether the cylinders shall be vertical or horizontal, and the other as to whether the crankshaft shall lie lengthwise of or across the car. Neither point is of vital importance. Vertical cylinders and longitudinal crankshafts are by far the more common, but some very good cars have horizontal cylinders and transverse crankshafts. Vertical cylinders have some advantage on the score of accessibility; but where the body is to be provided with very numerous and commodious seats, horizontal cylinders allow the carriage work to be carried over the engine, instead of the car being extended to an inordinate length. Where the crankshaft is transverse, it is possible to employ a theoretically more efficient type of driving gear than where it is longitudinal; but hitherto, practice has not shown this theory to be perfect.

The Piston and Rings.

The piston is, in form, very like the cylinder, that is to say, it consists of a tube closed at one end. It is made a little smaller in diameter than the bore of the cylinder, so that it may slide freely in the cylinder, and not jam in it when it expands with the heat. In order to prevent leakage between the walls of the piston and cylinder, some three or four grooves are turned in the exterior of the piston near its closed end, and in each groove is placed a piston ring. These rings are generally bored slightly eccentric, and are cut through obliquely at the thinnest part. They are normally a little larger in diameter than the bore of the cylinder, so that they press against the walls of the latter when in action; and at such times the rings should be of perfectly circular form externally, and the cuts or "slots" should be very nearly closed.

Connecting Rod Bearings.

Near the closed end of the piston is mounted a spindle, the gudgeon or piston pin. The upper end of the connecting rod rocks on this pin, and it is important that the pin itself should not move, and that the means for fixing it should not get loose and drop away, or considerable damage may be done. It is not within our scope to detail all the devices that have been employed, but one of the simplest is to form one of the piston ring grooves coincident with the ends of the gudgeon pin which extends right through the walls of the piston. As the piston and connecting rod, being reciprocating parts, are subject to innumerable and sudden reversals of their direction of motion, they should be made as light as possible, consistently with being strong enough to withstand the explosions and convert the impulses into a rotary motion of the crankshaft. The gudgeon pin end of the connecting rod is called the small end, and the other the big end. The journals, or bearings, at the big end are adjustable, so that wear may be taken up from time to time.

The Crank Case.

The crankshaft is mounted in bearings in a casing called the crank case. The case is usually made of aluminum alloy for lightness; and, with bracket extensions, it forms a means of attaching the engine to the frame of the car; it also serves as an oilbath, into which the cranks dip as they rotate and splash the oil about so that a quantity falls into little ducts which lead to the bearings. The crank case should be made with handholes, through which the big end bearings may be adjusted; if they are large enough to allow of withdrawing the piston, so much the better. Another arrangement is to divide the crank case horizontally, and fix the crankshaft bearings to the upper part of the case. This allows of the lower portion of the case being detached without disturbing anything else, and when this part is removed, those above it can be dealt with as may be required. A combination of the two plans is best; as the second one entails a lot of upside-down working.

Where the crankshaft has more than two cranks, there should be a bearing on each side of each pair of cranks, otherwise there is a danger of the crankshaft bending, and even breaking, under its work.

Function of the Half-speed Shaft.

As each operation of the motor happens only once in two revolutions of the crankshaft, the firing of the charge and the opening of the exhaust valve are controlled by a shaft rotated at half the speed of the crankshaft. For this purpose gear wheels are fixed to the crankshaft and to the "half-speed shaft"; these wheels gear together, and the wheel on the half-speed shaft has twice as many teeth as the wheel on the crankshaft. On the half-speed shaft is fixed a cam, that is, a ring or collar bearing a hump or projection on its periphery. On this cam stands a rod or plunger, and this plunger is in line with the stem of the exhaust valve. Hence, at every revolution of the half-speed shaft (and so at every alternate revolution of the crankshaft), the cam comes round and lifts the exhaust valve, through the plunger.

The Exhaust Valve.

It should be pointed out that the term valve is used to express both a whole and a part. In the larger sense the "valve" means both the door and its frame—the disk and its seating; in its smaller sense it means the door or disk only. From the form of the disk, and the stem under the disk, this type of valve is called a mushroom valve. Owing to the length of the stem used in motors, the valve looks perhaps more like a flat-headed nail than a mushroom. The seating forms a shoulder in a passage communicating with the combustion chamber on the one hand and the exhaust pipe on the other. Sometimes the exhaust valve is arranged directly over the combustion space in the cylinder head, but more often it is arranged in an exhaust valve box at the side of the cylinder. The upper part of the stem works in a guide, and a plate or washer is mounted on the lower part of the stem. Between the guide and the washer there is a strong spring, which normally holds the valve tight down on its seating. The edge of the valve and the seating are generally beveled, and carefully ground to the same angle, so that the valve may be gastight when closed.

It will be remembered that the exhaust valve is only open during one of the return strokes of the piston. This corresponds to half a turn of the crankshaft, and to a quarter of a turn of the half-speed shaft. Hence the hump only occupies about a quarter of the periphery of the cam. In practice, it is found best to allow the exhaust valve to open before the piston has quite finished its driving stroke, and to close exactly at the top of the return stroke. The valve should open fully and close completely as promptly as possible, but each end of the hump must be inclined—the forward end to lift the valve plunger in ordinary running, the rearward end to do the same in case the engine is accidentally reversed. Were it not for this last consideration, the hump might have a radial or precipitous end. Sometimes a hinged arm is interposed between the surface of the cam and the foot of the plunger; this is useful in overcoming the transverse action set up by the inclines when operating directly on the plunger, and (when an adjustable arm is used) in providing means for controlling the motor by varying the lift of the valve. The exhaust passage or port, the valve itself, and the exhaust pipe should be of ample dimensions, so that the exhaust gases may be cleared out with as little resistance as possible. A good many motors are now constructed with a large chamber, into which the exhaust ports of all the cylinders open. This provides for more ready expansion of the gases than if they are led directly into the more or less restricted exhaust pipe.

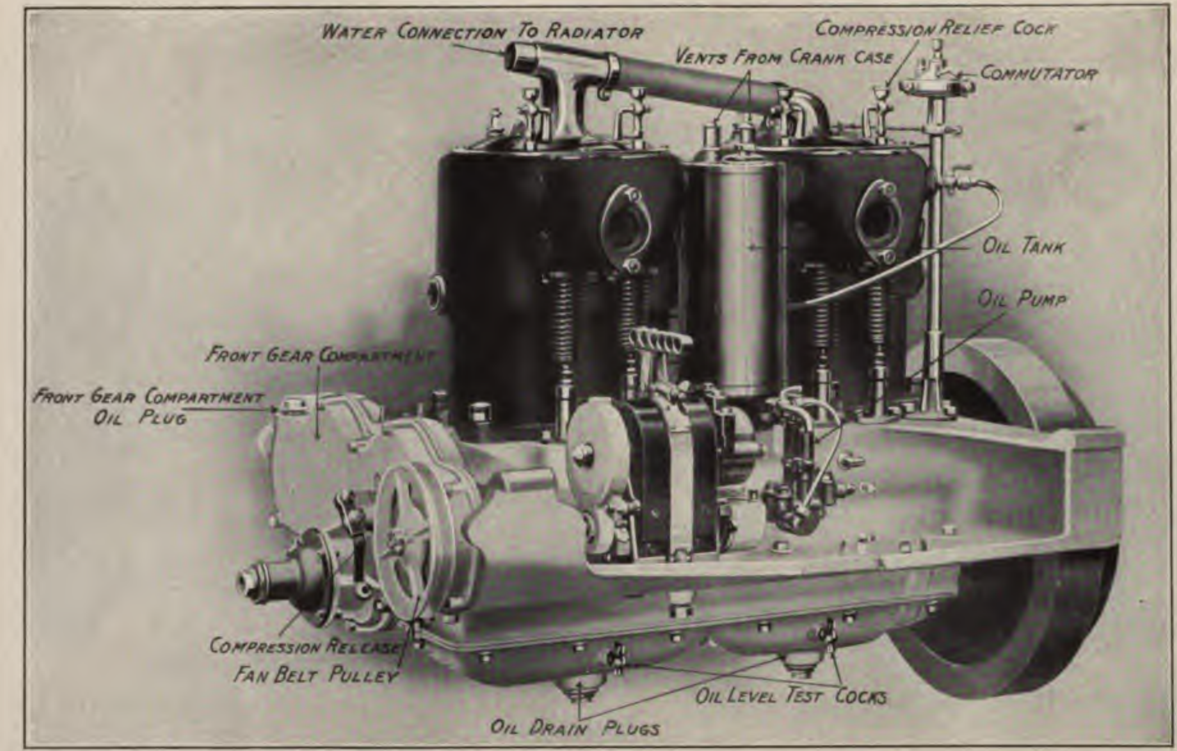
When the cylinders of the engine are separate castings, the branches of the exhaust pipe should be connected in such a way as to allow for a slight relative movement due to unequal expansion of the cylinders.

Silencing the Exhaust.

The object of the exhaust box is to silence or muffle the noise of the exhaust. At the same time it must allow of the ultimate egress of the gases as freely as possible, otherwise it will set up a back pressure, which will reduce the effective power of the engine. In the box are a number of tubes or plates, which turn the stream of exhaust gases first one way and then another, as in a maze, allowing them all the time to expand more and more, and ultimately allowing them to pass out through a number of fine holes or a pipe. These holes, or the pipe, should not point directly toward the ground; if they do, the exhaust will greatly augment the dust raised; and if they point backward it is very unpleasant for anyone behind, during a block in traffic. The box should be of good dimensions; and should be carried under the back part of the car, so that the occupants may not be troubled by any fumes emitted by it. Do not forget that the exhaust pipe and box get extremely hot, and nothing liable to be damaged by heat (fingers, tires, eatables, etc.) should be brought near them.

The Inlet Valve.

The inlet valve may be opened either by the suction of the piston, or positively like the exhaust valve. In the former case no special mechanism is required; the valve is made very light, and is normally held closed by a comparatively weak spring. Some prefer the automatic valve for high-speed work, and it is certainly simpler than the mechanically-operated valve. Where the latter form is employed, it is operated by a cam on a half-speed shaft like the exhaust valve. In fact, the valve parts can be made duplicates of each other, thus reducing the number of spare parts that should be carried. The contention that an engine with mechanically-operated inlet valves can be run slower than one with automatic inlet valves is to some extent supported by practice; any way, the former



The Packard Motor.

are more often used than the latter. But, however the valve is operated, the charge is drawn into the cylinder by the so-called suction of the piston.

The inlet valve is arranged in the port or passage connecting the inlet pipe with the combustion space. When it is located in the cylinder head, and is mechanically operated, the stem is directed upwards, and is operated on by one end of a rocking or see-saw arm, the other end of the arm being actuated by a long plunger rod. More often, however, the inlet valve is set head upward, like the exhaust valve, and is worked by a cam and short plunger. The inlet valves with their boxes may be arranged on the same side of the cylinders as the exhaust valves, in which case they are all operated from cams on a single shaft. This keeps down the number of parts, but crowds them together rather, and generally involves a long and tortuous inlet pipe, in addition to a tendency to unduly heat and therefore rarefy the induced charge. If the inlet valves are arranged on the other side of the cylinders, a second half-speed gear and shaft are necessary, but the various parts are rendered more easily accessible, and the timing of the exhaust and inlet valves can be regulated independently. This timing is a very important matter, as, unless the valves open and close just at the right times, the engine will not give off its full power. The close fitting of the valve head on to its seating is also important, and to facilitate the grinding-in of the valve, the head should be provided with a screwdriver slot. If the valve seatings are detachable, the grinding-in process can be conducted away from the rest of the engine, and the risk of the abrasive material finding its way into the cylinder is avoided.

The inlet and exhaust ports should be short, and, generally, the combustion space should be as free from pockets as possible, as these tend to retain portions of the exhaust gases which mingle with, and deteriorate, the incoming charges of combustible gas. Externally, also, the motor should present a clean appearance, and all fixings should be well secured and readily accessible.

Internal Gear—A wheel or gear whose cogs are on the internal perimeter.

Internal Wipe Contact Breaker—See under Ignition.

Interrupter—Any device for interrupting or breaking an electrical connection.

Interrupter Catch—A term used in connection with low tension magneto ignition to describe the catch which, acting on the striker, breaks contact in the cylinder.

Inverting Bolts—A trick worth remembering in overhauling a car is that there is always likely to be a greater or lesser number of bolts that can be rendered more accessible—at least in the user's opinion—by simply inverting them, though to do so may possibly impair in some slight degree the workmanlike appearance admired by the designer or manufacturer responsible for it. Of course, care must be taken not to invert any bolts that have a better reason than appearance for being the other side up, and it is to be remembered that a bolt dropping out is apt to be materially worse than a nut dropping off. But, with cotter-pinned nuts, for instance, there is little sense in working the wrench in frame channels, etc., when the head of the bolt might better be there.

Involute Wrench—A wrench of which the holding parts are involute or rolled spirally inward.

Involuntary Stops—Of course, the car may pull up for defects other than those connected with the engine, but the most frequent causes of stoppages (with the exception of tire troubles) are due to failures of the motor. With a little experience one can often guess the cause of the trouble from the way in which the stoppages occur. Thus, if the firing cease suddenly, it is probably due to a breakage in the electric system, or to the seizing of one of the pistons, or to one of the valves sticking or breaking, or, lastly, to obstruction of the carbureter. On the other hand, if the engine expires gradually, the trouble probably arises from failure of the water circulation, or the supply of gasolene or lubricating oil, or to the choking of the gauzes in the carbureter by dust or ice, or to the leakage of the float or of the compression. Thirdly, if the firing is intermittent, it indicates a discharged battery, a loose electrical connection, or a cracked sparking plug. We do not mean to say that this analysis is exhaustive, but it is a guide which will generally be found correct.

Failure of Gasolene.

We will consider some of the defects to which the various elements of a car are subject. If the gasolene is fed from the tank by gravity, the supply may cease owing to the fact that air is unable to enter the tank. The remedy is to unscrew the cap and let more air in. The cap should have a small airhole in it. Some tanks are provided with two caps, one having an airhole and the other not. The former is used during running; and evaporation is prevented by using the latter at other times. If the gasolene be fed under pressure, failure of the pressure will, of course, cause failure of supply. The most common cause of failure of supply is that the stock is exhausted. This generally means negligence, and it is always a good plan to carry one or two spare cans of gasolene to be used in case of emergency.

Carbureter Complaints.

The carbureter's most usual complaint consists in stoppage of the jet by some solid particle carried into it by the gasolene. If this be suspected while the car is running, the air supply may be reduced suddenly, so as to cause increased suction at the jet. If this does not remove the obstacle, one should agitate the float. If the carbureter floods and overflows from the jet chamber, the trouble has probably been got over; if it does not, the passage to the jet should be opened, and a fine wire pushed through. Do not use a needle or other hard wire for this purpose, as it may break off in the jet. A piece of florist's wire, or wire off a mineral water bottle, if not too thick, will serve very well. If the carbureter is provided with a well or filter, this should be opened, so that the precipitate may be removed. The cock in the gasolene supply pipe should be turned off first, otherwise a quantity of gasolene will be wasted. Or it may be found that water has collected in the carbureter; this may be removed in the same way by emptying the well.

Float and Needle Defects.

A more awkward situation is created when the float leaks; this, of course, upsets the balance of the carbureter, and prevents the gasolene standing at the right height. One can easily tell if there is gasolene in the float by taking it out and shaking it. To cure the trouble, warm the float and apply a light to it; the gasolene will be vaporized, and will catch light at the hole by which it entered. Put out the flame, mark the hole, and, if it is not large enough to pour out the gasolene through, make another hole in the top of the float and pour it out through that. When the float is empty, re-solder both holes, using as little solder as possible, so as not to alter the weight of float. This method should only be resorted to in an emergency, however, as it might result in much more harm than good. Another way is simply to remove the float and regulate the supply to the jet by the cock in the feed-pipe.

A defective needle valve will upset the working of the carbureter. If it arise from bending of the needle, it may be remedied by straightening the needle, and, if necessary, regrinding-in the valve. This grinding operation is similar to that of grinding-in the motor valves. See Grinding-in Valves. Sometimes the gauze screens through which the air and gasolene are admitted get so clogged up with dirt that the supply of these two fluids becomes insufficient. A little careful cleaning is all that is required. In cold, damp weather a block of ice will sometimes form on the gauze screen at the carbureter end of the inlet pipe, and the simplest way to deal with this is to remove the screen. Many carbureters are provided with heating arrangements, and if these are fitted with a cock, the cock should be opened on such occasions.

Ignition Troubles.

The ignition is a most fruitful source of stoppages, especially when on the battery and coil system; and the spark gap device, if not of much use as an intensifier, is certainly of considerable value as an index of the state of the system. If a good spark is shown at the gap one may fairly conclude that the ignition is in fair order up to that point, and first attention may therefore be given to the sparking plug. If there is no spark gap, one may detach the high-tension wire from the plug and hold the end about a quarter of an inch from any metallic part of the engine. Hold the wire by the insulation, and, better still, wrap a thick cloth round this; then turn the starting handle, and see whether a good spark passes from the end of the wire. If it does, unscrew the plug from the cylinder, and probably you will find that the points, and very likely the end of the porcelain also, are covered with a carbon deposit. Clean this off with gasolene and an old toothbrush, and polish up the faces of the points with fine emery cloth. See that the points are in line, and about a millimeter (or 1/25 in. to 1/26 in.) apart; some recommend 1/32 inch. Examine the porcelain to see that it is not broken, cracked, or loose. Also make sure that the central wire is properly secured; if it can twist round, the spark points may get out of line when the high-tension wire is attached, and then, of course, they will be too far apart for the spark to jump. The porcelain may be tightened by carefully screwing in the gland nut.

Now reconnect the wire to the plug, and lay the plug on the motor, so that only the metal body thereof is in contact with it. Turn the starting handle again, and see whether a good spark occurs at the points of the plug; if it does not, try another plug. Do not forget to switch the current on while testing. It should be remembered that water is a good conductor, and that if the exposed part of the porcelain is wet, the current will pass through it instead of across the points. Drying the porcelain will suffice in this case.

It may be, however, that no spark passes from the end of the high-tension wire, or that, though a spark is obtained, it will not continue for any length of time; and the test should always be continued for, say five or ten seconds. If the sparking gets weaker and perhaps expires during this time, it shows that the battery is run down, and such current as it gives is only due to temporary recuperation. This should be remembered when testing the high-tension wire or the plug. The condition of the battery, if of the primary or dry type, may be tested by an amperemeter, or "ammeter", which should read at least six amperes. If it is a wet or storage battery, a voltmeter should be employed, and should show over 3.8 volts. In each case the test should be made quickly. Some voltmeters are so constructed that their indexes come to rest promptly, and they are to be preferred for this reason. Instead of using a voltmeter, one may employ a four-volt test lamp. If this glows, and continues to glow brightly for some five or ten seconds, it may be gathered that the battery contains a sufficient charge, but not otherwise. Use the devices by applying their terminals to those terminals of the battery to which the low-tension wires are connected. If the meter shows nothing at all, reverse the application of its terminals.

If the battery is down, it must either be supplemented by another or recharged, if capable of recharging. Thus, if a two-cell accumulator shows only about three volts (and it should never be allowed to get so low), a single primary battery of about 1.5 volts may be coupled in series with the storage battery and a good current of 4.5 volts obtained. Of course, the right plan is to carry duplicate batteries, so that when one gives out the other may be brought into use. It is just as well to switch over on to the spare battery now and again to make sure that it is in good order, but most of the running should be done on one battery, and then when that is exhausted it can be recharged while the spare is in use. By having a third battery, one can be on charge without depriving the car of its reserve.

Reviving Run-down Batteries.

Although the primary cells are generally reckoned as done for when they have once given out their supply, they can sometimes be temporarily revived to some extent by merely allowing them to stand; and more positively, by making a solution consisting of one part of sulphuric acid and four parts of water, and introducing the same through the venthole of each cell; about a dessertspoonful may be squirted in by means of a small clean oilcan. If the cell will not take the whole charge at once, the operation must be performed in stages. If the venthole is too small, one can make a hole in the marine glue or other material with which the cell is sealed, and introduce the solution through it; the hole being afterwards closed by warming the glue and squeezing it over the hole, or by running in sealing wax. Storage batteries may be temporarily revived by steeping them for several minutes in hot water.

Sometimes it is found that batteries, instead of holding their charges for the proper time, will run down very quickly. This may be due to the primary circuit being left complete accidentally—the driver forgets to switch off after a run. Or it may be due to a short circuit in the wiring; or, again, to some of the paste dropping out of the grids and touching both a positive and a negative plate, thus forming an internal short circuit. Or it may be caused by a leak past the partition between the two cells. If the battery has a transparent celluloid case one can see whether any loose paste is causing a short circuit. To test for a leak past the partition, some of the acid should be poured out of one cell; then, if there is a leak, the acid in the other cell will pass through, and the levels of acid in the two cells will be restored. A leaking partition should receive immediate attention.

Detecting Short Circuits.

Where a short circuit is suspected, it may often be discovered by testing the ignition in the dark, as a spark will be noticed as passing from the defective point. The "short" is most liable to occur in the high-tension circuit, that is, in connection with the wire leading from the coil to the sparking plug; and the short should be looked for while the wire is in the position it generally occupies on the car, as the mere act of moving it in order to make the test above described may prevent the occurrence of the short circuit from which it suffers. It is a great mistake to purchase cheap insulating wire, as a few dischargings of the battery will more than make up the difference between the costs of the cheap and best quality wire. If, on examining the wire, one finds parts that are chafed, they should be carefully bound with insulating tape, and steps should be taken to secure the wire so that further rubbing will be prevented. A better plan is to slip a length of rubber tubing over the wire, or to replace the wire with a new length.

The wires should be kept as free from oil as possible, as oil rots the insulation, and thus invites short circuiting. If the insulation appears to be quite sound, the trouble may arise from breakage of the wire itself. If the wire be passed through the fingers with a bending movement, the break will probably be easily felt; but if not, it may be detected in the case of the primary wire by the voltmeter. The battery, suspected wire, and voltmeter, should be formed into a circuit for the purpose; some tension and twisting movement should be put on the wire during the test. If there is current in the battery, but none can be detected through the wire by the voltmeter, there is evidently a break. The wire should be replaced by another if possible, but if no spare wire is available, the defective one should be cut through at the fault, the insulation slit lengthwise and peeled back for about one inch on each part, and the ends thus bared should be twisted together. The insulation may then be turned back over the joint and the whole bound with insulating tape.

Terminals and Connections.

Though the electricity is willing to adopt all sorts of channels in order to shirk its work, all contacts through which it is intended to pass should be thoroughly clean, and should be scraped with an old knife for this purpose. Avoid using a knife on which you set any value for scraping the terminals of the battery, as you will be very likely to make contact accidentally with both terminals at once, to the great detriment of the blade, not to mention the battery. In order to avoid corrosion, the battery terminals may be anointed with a mixture of vaseline and ammonia.

There are many different devices (also going by the name of terminals) for connecting the wires to the different screws, etc. These are generally more satisfactory than making loops on the ends of the wires themselves, though one has to take care that the attached terminals do not project and touch each other or other metal parts, and so cause short circuits. It is perhaps easier to tell what to avoid than what to do in making terminals out of the ends of the wires themselves. Thus the wire should not be twisted up into an eye of which one part is thicker than another; nor should the eye, when made, be soldered with acid flux, as this brings about corrosion and fracture. If the eye is soldered at all, resin should be used, but the sudden stiffening of the wire by any soldering is also liable to cause breakage.

Probably the simplest way to make an eye is to untwist the wire at a short distance from the end, and then to separate the straightened strands equally by pushing a sharp instrument in between, forming a hole sufficiently large to receive the screw terminal. A stronger eye may be made by baring a good inch of the wire and bending it into a simple loop, and then binding together with fine wire the two parts lying in parallel contact, leaving an eye of suitable size, as before. In securing the one terminal to the other, be careful that no part of the insulation is pinched, as this would tend to prevent perfect contact between the metallic surfaces; at the same time, the insulation should be continued as nearly up to the connection as possible; and for further security, the whole connection may be wrapped with insulating tape. If a detachable plug form part of the primary circuit, and be lost, the two lengths of wire should be coupled together, the switch being relied on for breaking the circuit when required. Or a screw or nail, or a piece of wire doubled up into the form of a rod, will serve as a substitute.

Care of Trembler Points.

Another cause of intermittent firing is looseness of the platinum point on the trembler blade of the contact breaker. The presence of dirty oil on the back of the blade round the platinum is ground for suspecting that the point is loose. Under these circumstances the blade should be detached and laid face downward on a hard surface while the back of the point is riveted over with a light hammer. The faces of the platinum points should make contact squarely with each other; but the passage of the current and the tapping of the one point on the other spoil the surfaces in course of time, and the usual remedy is to file them flat with a thin, watch-maker's file. As platinum, however, is somewhat more expensive than gold, it seems a pity to waste it by filing, and the better plan is to hammer it smooth with a few light and carefully-applied blows. In some cases, too, the distortion of the surfaces can be corrected from time to time by changing over the wires on the battery terminals so as to send the current the reverse way through the points. But if the reversal of the wires is accompanied by the failure of the ignition, or excessive sparking at the contact breaker, they must, of course, be replaced. In any case, no dirt should be allowed to remain between the platinum points, though a drop of oil there is sometimes found to be an advantage rather than otherwise. The points may be cleaned by inserting a thin card or a slip of strong paper between them, and then withdrawing the card while the points are pressed together. Be careful that no particles of paper are left behind, as they will be as bad as, or worse than, the dirt.

Adjusting Contact Breakers.

In adjusting a make-and-break contact breaker one has to see that the cam projection lifts the blade into contact with the screw, and that when the projection has passed, the points are out of contact. Provided the points make a good firm contact, nothing is gained by the excessive bending of the blade, but rather the reverse, as current is wasted by the prolonged contact.

Unscrew the sparking plug and lay it on part of the metal work so that one can see the spark, and so that the terminal end of the plug lies clear of the metal work. Then fix the contact screw at that position which corresponds with the best spark at the plug. Notwithstanding the action of the condenser, a small spark will be noticed as the points at the contact breaker separate. In fact, if no spark shows here it is a pretty sure sign that either the battery is run down or there is a fault in the primary circuit.

Wipe contact breakers are generally self-adjusting by means of a spring. They should, of course, be kept clean, but they should be freely oiled; the reason for this being that if they are run dry the wipe tends to scrape particles off the metallic segment and embed them in the fiber cam, thus constructing a path through which the current will continue to pass after it should be broken, and disturbing the timing of the sparking and wasting the current. Any such particles should be removed; and the metal and fiber surfaces should be kept even with one another, as inequalities frequently cause the wiper to jump, with irregular firing as a result.

Coil Troubles.

When every other part of the ignition system has been proved to be in order, one can only conclude that the trouble is in the coil. This may be due to failure of the insulation. If, on the system being connected up and the contact breaker being worked, a ticking noise be heard in the coil, this is a pretty sure sign of defective insulation. The only remedy is to get the coil repaired by an electrician, preferably the coil-maker himself. The trouble, however, may arise from loose connections at the coil, or from loose strands of wire causing a "short" from one coil terminal to another. These troubles can, of course, be easily remedied if they occur at the exposed ends of the terminals; but if the shorting is between the inside connections, the cover must be carefully removed so as not to break the wires, and as carefully replaced in its proper position after correcting the fault.

If the coil trembler suddenly stops work, it is probably because it has stuck. Should this happen, the trembler may be set in motion again temporarily by unsticking it, but the platinum-pointed screw should be readjusted as soon as possible. The platinum points should be inspected, and, if necessary, cleaned and reshaped; they should stand normally about half a millimeter apart, but it is best to effect the adjustment with the sparking plug where the points can be seen, so that the platinum-pointed screw can be locked at the position which shows the best spark. The tightening of the locknut on the screw will generally upset the adjustment somewhat, and this must be allowed for by setting the points a little too close together before finally tightening up. If this adjustment will not cure the trouble, the defect may lie in the loss of elasticity in the spring blades; if so, they must be replaced by new ones.

Ion—One of the chemical products of electrolysis. See under Electrolysis.

Iridium—A non-malleable metal of a whitish color, found in the ore of platinum and in a native alloy with osmium. Used for making electric terminals, in spark plugs, etc.

Iron—The commonest and most useful of all the metals. Cast iron contains about 3.5 per cent of carbon, wrought iron about 0.4 per cent; intermediate between the two is Steel, which contains about 1 per cent of carbon and possesses properties that render it perhaps the most important form in which this metal is employed. In the forms of both cast iron and steel it enters very largely into the construction of automobiles, and modern manufacturers are constantly on the lookout for improved varieties of steel and iron suitable for their purposes.

Iron, Angle—A piece of iron rolled into the shape of the letter L or V, used for forming the joints of iron plates in girders, etc., to which it is riveted; used in making automobile frames, etc.

Iron, Bar—Weld iron or wrought iron in bars.

Iron, Black—Untinned cast or wrought iron.

Iron Cement—See under Glue and Cement.

Iron, Channel—A flanged iron beam or piece of any size whose section is that of three sides of a parallelogram; used in construction work and also called channel bar.

Iron, Charcoal—Iron smelted in furnaces heated with charcoal.

Iron, Circle—A horizontal circle of iron between the fore axle and the body of a horse vehicle; also called the fifth wheel.

Iron, Dumb—See Dumb Iron.

Iron, Galvanized—Iron coated with zinc by galvanic deposition; or iron, usually in sheets, coated after cleaning by immersion in melted zinc.

Iron, Gray—Cast iron containing graphite.

Iron, Magnetic—Magnetite, a ferrous oxid, also called magnetic iron ore and when it possesses polarity, lodestone.

Iron, Malleable—Malleable iron castings are prepared from ordinary fine grained castings by a treatment such as heating for a lengthy period in manganese dioxid, which eliminates the free carbon of the casting. Malleable cast iron is used for many fittings where a forging or steel stamping would be better if cheapness were not considered of more importance than strength. It is, of course, more ductile and of greater tensile strength than cast iron, but is much less ductile and weaker than wrought iron or steel. Its use on the motor car should therefore be very restricted.

Iron, Meteoric—Iron, usually alloyed with nickel and cobalt, found in meteorites or mineral masses that have fallen to earth from space.

Iron, Pig—Iron cast in pigs or oblong masses.

Iron Plate—A piece of iron flattened or extended by rolling to an even surface with a uniform thickness.

Iron, Refined—Pig iron partially decarburized and purified in the open-hearth furnace to render it more suitable for puddling, or conversion into malleable iron.

Iron, Russia—A hard glossy variety of sheet iron which does not rust readily.

Iron Rust—The red or orange-yellow coating which is formed on the surface of iron when exposed to air and moisture. It is a red oxid or peroxid of iron.

A composition of iron filings and sal ammoniac, with sometimes a little sulphur, moistened with water and used for filling fast joints is also called iron rust. Oxidation sets in rapidly and the composition after a time becomes very hard and takes thorough hold of the surfaces between which it is placed. A joint formed in this way is called a rust-joint.

Iron, Sheet—Iron which is rolled or formed into large, broad and thin sheets.

Iron, Soldering—A tool for applying solder; it consists of a copper bit or bolt having a pointed or wedge-shaped end, fastened to an iron rod with a wooden handle.

Iron, T—A rolled wrought-iron bar whose section is like a letter T.

Iron, Weld—Iron intermediate in percentage of carbon between cast and wrought iron.

Iron, White—A whitish crystalline variety of cast iron.

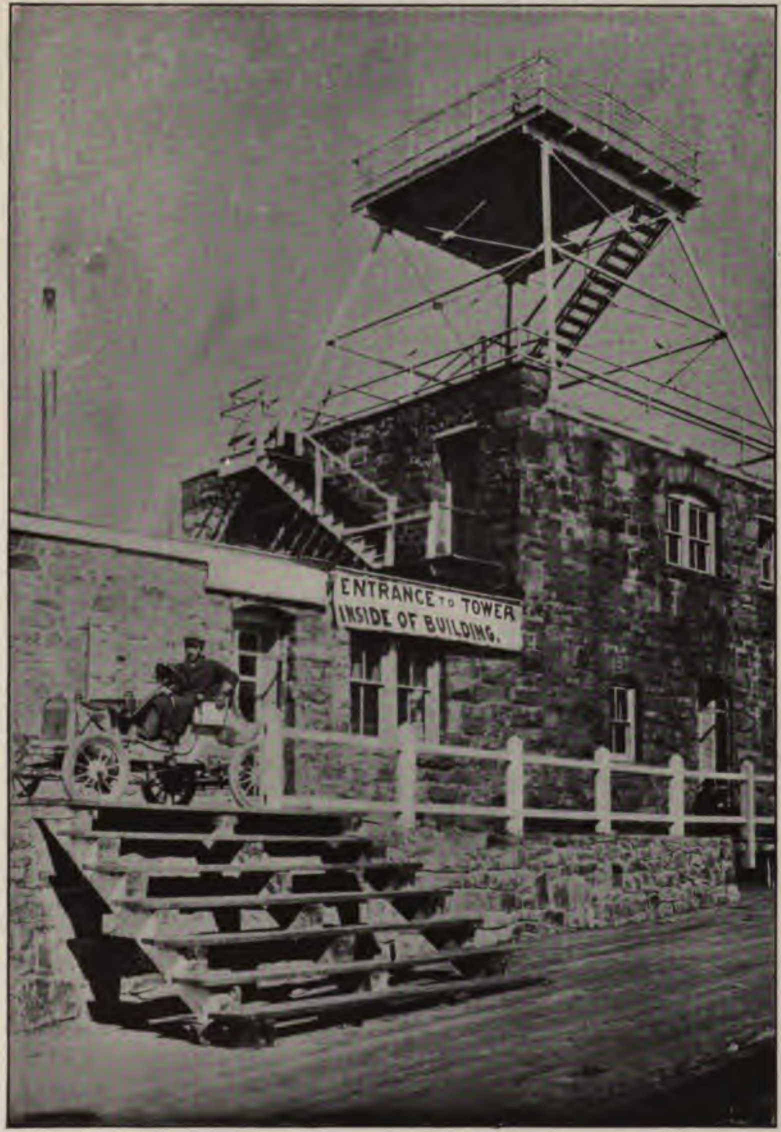
Iron Wire—See under Wires.

Iron, Wrought—A soft, ductile, tough and malleable iron containing a very low percentage of carbon. It will not temper and cannot be easily fused.

Irregular Firing, A Cause of—See under Driving; also under Ignition.

Irregular Knocking—Irregular knocking in an engine may come from loose electrical connections in the primary circuit, a commutator pole that grounds occasionally when in a certain position, a loose flywheel, or premature ignition from overheating.

A regular knock or pound will come from spark set too early



The Brush Runabout on the Upper Platform, Summit of Pike's Peak.

or a loose bearing or transmission, possibly a gear loose on a shaft. An unevenly timed engine causes unsteady running on low speeds.

Irregular Missing—Irregular missing will be caused by a dirty spark plug, wrongly adjusted or sticking coil trembler, platinum points on a trembler burned off or pitted or dirty or loose in the spring, poor commutator contact or ground; if accompanied by an irregular knock it will be usually a loose commutator wire. Sometimes a secondary wire has had the insulation worn off and the current jumps outside the cylinder. Cracked insulation on either mica or porcelain plugs gives trouble. A primary wire may be broken inside the insulation or may have a dirty connection or be nearly worn through and only a strand or two holding.

Shooting in the muffler will come from either too rich a mixture or electrical trouble. Backfiring in the carbureter from too weak a mixture and may be dirt in the carbureter, too small a fuel pipe or a leaky inlet valve. Too late a spark and open throttle will cause it.

An engine will pick up suddenly or slow down without apparent cause if the commutator is loose on its shaft, if the control rods on commutator or throttle have lost motion in them, or if a fuel level is low, or with loose light dirt in the carbureter.

With a magneto and battery equipment it is claimed that less fuel is required in the mixture when the magneto is used and that on high speeds the proper mixture with the magneto will back fire with the battery.

Irreversible Steering Gear—See under Steering.

J

J—In thermodynamics, J denotes the mechanical equivalent of heat, known as Joule's equivalent. See Joule.

Jack—An instrument by means of which a heavy weight can be lifted. Used for motor cars to lift the wheel clear of the ground for tire repairs or rim detachment purposes. It is generally in the form of a screw, sometimes with a ratchet mechanism on the end of a lever to operate the screw. In the best made jacks an arrangement is provided by means of which the jack can be brought up to its work speedily without the tedious rotation of the screw. Considerable attention has been devoted to the making of efficient jacks for motor purposes, so that they may be quickly adjusted in position. Such jacks can be conveniently carried on the car, and should always form part of the car and garage equipment. See Tools.

Jacket—A covering placed around a cylindrical or other vessel of any kind, as a steam boiler, to give greater power of resistance, to prevent escape of heat by radiation, etc. Felt, wool, asbestos, paper, wood and other materials are used as jackets.

Jacket, Cylinder, Patching A—See under Cylinder.

Jacket, Steam—A cavity for steam surrounding a cylinder, intended to heat the cylinder and prevent loss of steam by initial condensation.

Jacket, Water—A device using water to keep something cool or at a certain temperature, as the cylinder of a gas engine. See Circulation; Water Cooling.

Jack-in-the-Box Gear—A toothed wheel mechanism comprising the rotation of a wheel on an axis which simultaneously moves radially around a fixed center.

Jackshaft Broken—See Miscellaneous Roadside Repairs.

Jam—To thrust or squeeze in so as to stick fast.

Jamb—An obsolete spelling of Jam.

Jammed Clutch—See Repairs and Adjustments.

Jamming—The stoppage of motion in a part of machinery by unusual pressure. Jamming friction is the friction produced by the jamming or pinching action of cams, eccentric-rollers, etc.

Jamming occurs in bearings through overheating or lack of lubrication.

Jam Nut—A jam nut or check nut, is distinctive from a lock nut owing to the fact that it is fitted on a thread running in an opposite direction to that of the nut which it is intended to jam or lock. Thus a right-handed nut may be locked on a spindle by arranging a left-handed thread at the end of the right-handed thread on the spindle and screwing onto it a left-handed nut. The tendency of the right-handed nut to unscrew causes it to go up against the left-handed nut, and to turn it in the same direction so as to jam up against the right-handed nut on account of the different directions of the thread.

Jaw—A term applied in mechanics to anything resembling a human jaw in form or use; especially the side of a frame of a machine holding a journal-box in place; a housing. Also one of two relatively movable members used to hold, cut or crush an article placed between them.

Jaw Bolt—A bolt with a U-shaped split head, perforated to carry a pin.

Jaw Clutch—See Clutch.

Jet—Otherwise Nozzle or Nipple. The device whereby the gasolene in a carbureter is atomized or sprayed, being drawn through the jet by the suction of the engine. Jets are also used in the liquid fuel burners of steam cars.

Jet, Choking of Gasolene—See under Driving; also under Involuntary Stops, Repairs and Adjustments, etc.

Jew's Pitch—A name sometimes given to bitumen.

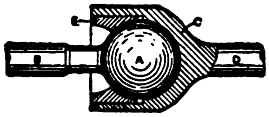
Jig—An appliance used almost exclusively in the manufacturers' shops. Its object is to fix a considerable number of parts in rotation on the machine tool in which they are being machined.

Jockey Pulley—A jockey pulley is used to take up the slack in a belt, more particularly in cases where the belt has to run on pulleys of different sizes—when, of course, it is not the correct length for some of these. The extra length is taken up by depressing the belt by means of the pulley. Jockey pulleys are used on some forms of motor cycles where a straight drive of the belt from one pulley wheel to the other is not obtainable by reason of the nature of the design.

Joints—A general term used to describe different methods of attaching one member to another. See Packing; Soldering; Gland; Gasket. The principal forms of joint are as follows:

Airtight Joint—A joint which will not allow air or gas to escape, or will not admit either. In the case of automobiles such joints are necessary on pressure feed gasolene supply installations. Both the tank and its connections, and the pipe leading to the source of air pressure, must be coupled up with airtight joints.

Ball and Socket Joint—A ball and socket joint is a joint which may be used either for pipes for conveying fluids or gases or to transmit motion. It consists of a spherical projection at one end of one member of the joint, fitting into an internal spherical recess in the other, the joint being usually ground in position. A screwed-in gland keeps the two spherical surfaces in close contact. This joint is not capable of transmitting rotary motion, but is often used in the steering joint of cars where a double angular motion is required, thus dispensing with one joint. Movement in a ball and socket joint may be made in any direction within certain angular limits. Our illustration depicts a type frequently used. A is a ball formed on the end of the shaft or tube B, C being the socket on the shaft or tube D. The ball is held in position by means



Ball and Socket Joint.

of the gland E, which also admits of the joint being adjusted to take up wear. The cap is held in position and prevented from slackening off by a small screw or split pin. It will be seen from the illustration that the range of angular displacement of the joint is confined in every direction to that angle at which the shaft B comes in contact with the edge of the gland E.

Cardan Joint—See Shafts; Cardan Shaft.

Expanded Joint—A steam-tight joint between the end of a pipe and the shell of a boiler. A hole is bored in the shell the same size as the outside diameter of the tube. The tube is then inserted into the hole, so that the end protrudes slightly. This end is then expanded into intimate connection with the boiler shell by means of a coned instrument which opens out the end of the tube. Only used for the water tubes or fire tubes in boilers. See Expander.

Expansion Joint—A joint in a pipe which is capable of a certain amount of longitudinal movement. It is used in steam pipes to allow of the pipe expanding and contracting at varying temperatures without putting any strain on the various parts to which it is fastened. On modern motor cars expansion joints are often fitted in the exhaust pipe between each separate cylinder, which insures that when the exhaust pipe becomes hot and expands it will not put any strain on the couplings, or tend to force the cylinders away from each other.

The most usual type of expansion joint is the gland joint, which is, to all intents and purposes, a large edition of the stuffing box used for steam engine piston rods. The end of one pipe enters a socket on the end of the other. This practically forms a stuffing box, and is filled internally with any suitable kind of packing. The outside gland is screwed into this, pressing a packing round the inserted pipe, and as either of the pipes expand or contract in length, they slide about each other—the stuffing box keeping a tight joint. Instead of having a packed joint, in steam car practice it is often useful to take advantage of the elasticity of the metal of which the pipe is made. In some cases the pipe is turned up into the form of a U, so that the expansion and contraction have the effect of bringing the ends of the U nearer or farther apart without any frictional movement. The U-shaped piece of pipe, simply by its elasticity, allows for this end movement. If the pipe is turned round into the form of a coil it will also expand and contract without the need of a moving or sliding joint.

Flange Joint—A flange joint is used to couple two pipes together, or to couple one pipe to an outlet or inlet of a vessel. Flange joints are often used to couple the inlet or exhaust pipes to the cylinder, or the water pipes to the cylinder jackets. Where two pipes are joined together, these are provided with flat plates forming faces which are bolted together by means of two or more bolts, sometimes packing being inserted between the two faces. Similarly, when attached to cylinders or cylinder jackets, they are provided with plates which form joints with flat-machined surfaces on the cylinder walls.

Flexible Joint—A flexible joint is one which allows of a certain amount of movement relatively to two rotating or reciprocating parts. In one sense of the term, cardan and universal joints are flexible joints, but the term is generally used to denote the junction of two shafts by means of a flexible connection, such as a spring, so that not only may the shafts move their position relatively to each other, but also their rotation may, within the limits of the flexible joint, alter relatively to each other. An instance of this is found in the case of spring couplings between the shafts which drive pumps (found in water-circulating pumps and in oil-circulating pumps). The forced lubricating pump of the De Dion engine is a typical example.

Flush Joint—In cases where it is necessary that a joint in a pipe should not increase its diameter or alter its outside shape, a screw nipple may be inserted so as to join both pipes together from the inside, or they may be brazed together so that they are flush with each other inside and outside. A flush joint may also be made by screwing a socket over the junction of two pipes (see Socket Joint), in which case it is flush inside instead of outside.

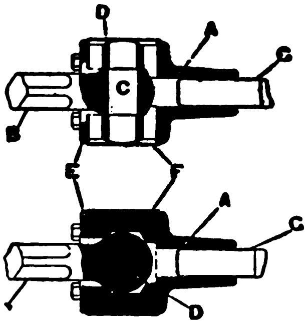
Socket Joint—In joining two pipes by a socket joint their ends are screwed for some distance and each end is inserted in an internally screwed socket, and screwed home in the socket to butt up against the other. It will be seen that in fitting up a joint of this description it is necessary that one tube should be rotating in relation to the other, so that if both tubes are fixed and incapable of rotating the usual socket joint cannot be used. To get over this difficulty, however, the socket may be screwed on the end of one tube, and then be screwed back across the other tube, so that the joint lies immediately in the center of the socket, and a back nut screwed up against the face of the socket to make the joint tight. In a similar case, where it is possible to move the ends of the pipes a little way from each other and yet in a position to face each other, a socket with a right and left-hand internal thread may be used, one of the pipe ends being screwed right-hand and the other left. The simple rotation of the socket will draw the pipes together and make a tight joint.

Screw Joint—Practically the same as Socket Joint, the parts to be joined being tightly screwed together.

Tee Joint—Where a pipe is intended to lead off another pipe a socket is used as in Socket Joint, with a projection into which a third pipe is screwed.

Toggle Joint—A joint formed by two levers, each of them pivoted on one end to members which are to be forced apart or brought together, and their other ends pivoted together. The toggle joint is very powerful. If pressure is brought to bear on the joint which couples the two levers, the leverage which can be obtained as these approach a straight line with each other is enormous in forcing the two pieces, to which they are coupled, apart; but, once the levers assume a position in which all the joints are in a straight line, no further effect can be obtained in forcing the parts away from each other, and if they pass this point and begin to draw together the pressure will be released. Toggle joints are often used to exert great pressure on brakes, or expanding clutches, but care should be taken to see that wear does not affect them to such an extent that in full operation they approach the position indicated, that is, with the levers in a straight line.

Universal Joint or Knuckle Joint or Cardan Joint—These Joints are of several forms, used for transmitting power from one shaft to another when they are not in line with one another or if there is a slight variation in position during working. The most common form is that in which the ends of the shafts adjacent to one another have each a fork on them, these forks being set at right angles to one another. Cross bolts then connect the two, so that each fork is free to swivel on a bolt which acts as a pivot. Universal joints are used in propeller shafts, clutch shafts, etc. See Shafts.



A Type of Universal Joint.

The illustration shows a type of Universal joint. A is a fork mounted on the gear box shaft G, having a stem provided with a square section hole, which is free to slide over the shaft G. This fork is also slotted and bored to take the ball end B of the propeller shaft. Shrunk into this ball end is a transverse pin C, which is free to turn in two square sliding blocks D, sliding in the slotted jaws of the fork A. E is the cap which retains the ball end in position, F being a dust cover for the ball, held in position by the ball cap E. This method of construction is claimed to give a large wearing surface and consequent smooth action.

Joint, Bayonet—An end-to-end coupling, in which pins play in and out of slots made to receive them.

Joint, Bellhanger's—A method of joining wires in which the ends of the wires are bent and hooked together and then twisted about the body of the wire to form linked loops.

Joint, Butt—A joint connecting two square or solid parts endwise without overlapping.

Joint, Cardan—A universal joint. See Joints.

Joint, Compensating—Same as Slip Joint.

Joint Coupling—In shafting, a form of universal joint by which the sections are coupled and locked together.

Joint, Cup and Ball—Another name for the ball and socket joint. See Joints above.

Joint, Dovetail—See Dovetail.

Joint, Expanded—A joint made by expanding the end of a pipe or tube when fitted into a hole, as in a steam boiler, etc. A tool called an expander is used for the purpose.

Joint, Expansion—See under Joints.

Joint, Fantail—A dovetail joint.

Joint, Female—The socket or faucet piece of a spigot or faucet joint. A coupling with an internal screw thread.

Joint, Flange—See under Joints.

Joint, Flush—See under Joints.

Joint, French—A method of uniting wires in which the ends to be joined are laid side by side for a short distance and then twisted.

Joint, Hooke's—A device by which a motion of rotation is communicated from one shaft to another lying in the same plane, though in a different direction. A cardan or universal joint.

Joint in Plug—See Ignition Faults and Hints, under Ignition.

Joint, Jump—A butt joint: a joint made without lapping.

Joint, Knuckle—Same as Universal Joint. See Joints above.

Joint, Lap—A joint in which an edge of one of the parts connected overlaps the edge of another part, the edges being partly cut away so that the parts are in parallel relation with each other.

Joint-pipe—A short section of pipe forming a connection between two lengths.

Joint, Reducing—A coupling by which a pipe may be joined to another of larger diameter.

Joint, Rivet—A joint formed by riveting, as in the case of boiler plates, etc.

Joint, Rust—See Iron Rust.

Joints Faulty—See under Compression.

Joint, Screw—A joint formed by screwing one member into another.

Joint, Shackle—A joint made by a shackle or clevis with its bolt.

Joint, S—A joint made by means of a strip of material shaped like the letter S.

Joint, Sleeve—A joint made with a sleeve or tube within which the abutting ends of shafting, etc., rest or are coupled.

Joint, Slip—A form of joint permitting of a lengthwise slipping motion of one or both the parts joined; also called compensating joint.

Joint, Socket—See under Joints.

Joint, Spigot or Faucet—An expansion joint for uniting two parts of a straight metallic pipe which is exposed to great variations of temperature.

Joint Splice—Any reinforcing device for holding two parts of a structure or machine firmly in place.

Joint, Square—A joint for wood, etc., in which the edges are brought squarely together, without rabbeting, tongue or feather.

Joint, Swivel—A section in a chain or a joint on a rod, etc., which allows the parts to twist without distortion or kinking.

Joint, Tee or T—See under Joints.

Joint, Thimble—A kind of joint in which two ends are connected by a thimble made to fit each of them.

Joint, Toggle—See under Joints.

Joint, Union—A pipe coupling.

Joint, Universal—See under Joints.

Joule—A unit of electrical energy or work which is equivalent to the work done in raising the potential of one coulomb of electricity one volt, or in maintaining for one second a current of one ampere against a resistance of one ohm. One joule is equivalent to 10,000,000 ergs or .73732 foot-pound. Named after J. P. Joule, an English physicist.

Journal—That part of a shaft which runs in the bearing, such as the ends of the change speed gear shafts, which run in the bearings in the gear-box. See Bearings.

Journal, Axle—The immediate support of an axle. See Axle.

Jump—In blacksmithing, to unite by an end or butt weld.

Jump Joint—See Joint, Jump.

Jump Seat—A folding carriage-seat.

Jump Spark—The electric ignition spark produced by a high tension current from an induction coil. This term relates purely to the spark across the points of a sparking plug, and does not refer to the spark which jumps across the make-and-break inside the cylinder where low tension ignition is fitted.

Jump Weld—A butt or end-to-end weld.

Junction Plate—A piece of boiler plate used for uniting two plates which make a butt joint.

Junk Ring—A name applied to a ring fitting into a groove around the piston of a steam engine to keep it steam-tight.

K

K—The chemical symbol for potassium—abbreviation of its chemical name Kalium.

Kathode—A secondary spelling of Cathode, which see.

Keckling—Material used for wrapping ropes or cables to prevent wear—a sailor's term.

Keel—The principal timber in a ship extending from stem to stern, at the bottom and supporting the whole frame; in iron vessels a combination of plates or beams corresponding to this timber.

A vessel, etc., is said to be "on an even keel" when it is in a level or horizontal position.

Keel, False—A strong, thick piece of timber, etc., bolted to the bottom of a keel to preserve it from injury.

Keelson—A piece of timber in a ship, laid on the middle of the floor-timbers over the keel, fastened with long bolts and clinched, thus binding the floor timbers to the keel; in iron vessels, plates constructed and combined to correspond to this timber.

Keeper—That which keeps, retains or holds anything in place, as a locknut, ring, clamp, etc.

Keeping Rear Lamps Alight—See under Driving; Lamps.

Kerf—The cut of an ax, a saw or other instrument; the notch, channel or slit made in wood by cutting.

Kerosene—A volatile oil or liquid hydrocarbon distilled from coal, bitumen or petroleum. Called in England Paraffin, and in the United States Coal-oil. When of good quality it is nearly colorless and of specific gravity varying from 0.780 to 0.825. Its flashing point should be 65 Centigrade or 149 Fahrenheit.

Kerosene is used for injecting into the cylinder via the pet-cock or spark plug; it dissolves the gummy and sticky residue of lubricating oil. Do not, save exceptionally, use gasolene for this purpose—it evaporates too quickly to give any lubrication to the cylinder walls. When injected kerosene facilitates the starting of the engine, and for this purpose a small cup is fitted to the top of the combustion head. The objection to kerosene injection is the possible formation of a hard carbon deposit on the piston and cylinder. Small doses only should be used.

Kerosene Carbureter—A carbureter by means of which kerosene may be used as fuel in an internal combustion engine.

Kerosene Lamp—A lamp employing kerosene as an illuminant.

Kerosene Motor—An internal combustion engine in which kerosene is used as fuel, instead of gasolene or alcohol, etc.

Kerosene Pump Lubricator—See under Lubrication.

Key—A rectangular piece of metal used to secure a wheel to a shaft.

A slot half the depth of the key is cut in the shaft, and a similar slot is cut in the boss of the wheel, the latter having a very slight taper. The slots are placed opposite to one another; the key is inserted and driven up, and the wheel is thus firmly fixed to the shaft. More often the key is sunk in a recess in the shaft which just fits it endways, so that it cannot move along the shaft. The wheel is then pressed or driven along the shaft on to the key. It must not be confused with a cotter or taper pin. (See Pin.)

In cases where there is much power transmitted through the shaft and wheel, two or more keys are used. The slots into which the key or keys are driven are known as key-ways or key-seats. "Key" must not be confounded with "feather." The latter is used only to keep the wheel from turning around the shaft, and does not prevent it sliding along it, which it may be intended to do. (See Feather.) The word Key is also sometimes used to denote a spanner or wrench.

Fixed Key—A key which is sunk into a recess in a shaft or other member, and upon which the part to be fixed is forced endways.

Key—An instrument by which something is screwed or turned, as a lock, a clock, etc.

Key-bed—A groove or slot cut into metal for receiving a key, as in a shaft carrying a pulley, to prevent slipping or turning of the shaft in the pulley.

Key-bolt—A bolt held in place by a key passed through a hole near the end of the bolt.

Key Drift—A tool used in making a rectangular slot in the bore of a wheel or in the surface of a shaft. It consists of a tapered rectangular piece of hardened steel with teeth cut on its edges, and when driven in between wheel and shaft forms a tapered recess into which the key can be driven.

Key Driver—A square ended punch made of steel, used for driving keys out of the key-way.

Key in Cylinder, Dropped—See under Engines.

Key, Screw—A socket wrench for turning a nut or screw; also, a tapering wedge, the motion or position of which is controlled by a screw cut lengthwise upon it.

Key-seat—See Key above.

Key Sheared or Lost—See under Motor Stopping.

Key-way—The slot into which a key is driven.

Khaki—A light-brown or olive cloth used for military uniforms in warm climates, also to some extent for motoring garments.

Kilo—An abbreviation of Kilogram.

Kilodyne—In physics, a unit of force equivalent to one thousand dynes.

Kilogram—One thousand grams or 2.204 pounds. A standard weight in the metric system.

Kilogrammeter—In mechanics, a unit of work accomplished in raising a kilogram through a meter against the force of gravity.

Kilometer—One thousand meters or about five-eighths of a mile. See Metric System.

Kilowatt—A unit of electrical work or energy equivalent to one thousand watts.

Kinematics—That branch of physics which treats of motion in all its relations and modifications, irrespective of causes.

Kinetic Energy—The energy of motion, or the capacity of a moving body to do work.

Kish—A substance resembling graphite, consisting of carbon and manganese, found in some iron-smelting furnaces. It is the name given by furnacemen to the graphite which appears on the surface of the iron in a blast-furnace during the process of tapping.

Kit—An outfit of tools, accessories and spare parts carried on an automobile. See Outfit; Tools, Spare Parts and Accessories.

Kit-bag—Usually applied to the bag or receptacle in which the necessary tools, cleaning cloths, sponges, etc., required in the upkeep of a car are carried. See Outfit.

Knee—A piece of timber or metal cut or cast with an angle somewhat in the shape of the human knee when bent.

Knee-iron—An L-shaped angle iron used to strengthen a joint formed by two parts of a frame, etc.

Knife—An essential part of the old regulating device known as the hit-or-miss governor.

Knife-jack—A spring device for making electric connections.

Knife-switch—A chopper switch, used in magneto ignition systems for cutting out cylinders.

Knocking—A peculiar thumping noise in the engine which denotes that something is wrong. It is quite a distinct noise from the regular beat of the engine. See Knock, under Repairs and Adjustments; Noise, Pounding and Knocking.

Knocking in the Engine, Cause of—See under Engines; also Pounding and Knocking.

Knocking in the Engine, Cure for—See under Engines.

Knocking in Gears—See under Change Speed Gear.

Knocking, Irregular—See Irregular Knocking.

Knot—A union of cords, etc., by interweaving or interlacing.

Also, a nautical mile, varying with the latitude, but fixed in the United States navy at 6080.27 feet. The nautical mile is considered as equal to "the one-sixtieth part of the length of a degree on the great circle of a sphere whose surface is equal to the surface of the earth."

Knox Air-Cooled System—See under Air Cooling.

Knuckle-joint—Another name for a universal or cardan joint.

Knurled Nut—A milled nut. See Bolts and Nuts.

Knurling—A term applied to the roughened edges or heads of certain nuts, screws, caps, etc. See Bolts and Nuts.

Krebs Carbureter—See description and illustration under Carbureter.

L

L—Any common object, as a piece of pipe, when L-shaped.

Lac—A resinous substance deposited upon trees by certain scale-insects. After preparation it becomes the shellac of commerce, used in varnishes, lacquers, etc.

Lace or Lacing—In machinery, a thong or narrow strip of leather by which the ends of belts are joined.

Lack of Gasolene—See under Loss of Power.

Lack of Lubrication—See under Loss of Power.

Lack of Oil—See under Pounding and Knocking.

Lack of Pushrod Clearance—See under Loss of Power.

Lack of Water—See under Overheating.

Lacquer—An opaque varnish much used for woodwork and metal work, a solution of shellac in alcohol being the chief ingredient.

Ladies' Headgear—See Clothing; Dress.

Ladle—In founding, an iron vessel, often with two handles, in which liquid metal is carried from the furnace to the mold.

Lag—In mechanics, the quality of retardation of some movement, as the lag of a slide-valve. Also, one of the strips which form the outer covering of a drum, cylinder, steam boiler, etc. To "lag" a boiler is to cover it to prevent radiation of heat.

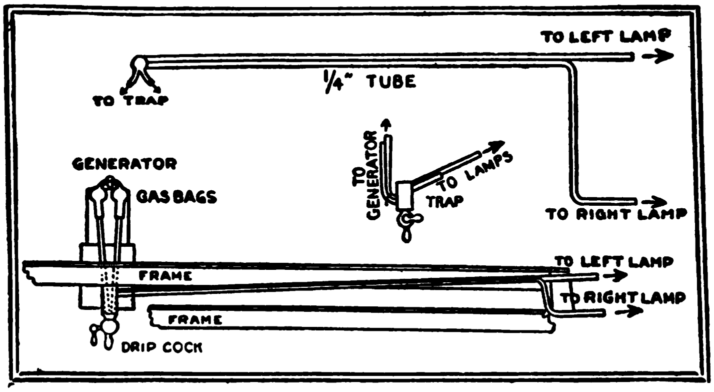
Lag-bolt—An iron bolt with a square or hexagonal head and cut with a wood-screw thread. It is cylindrical under the head, so as to admit of turning after it has entered the wood. Also called Coach-screw and Lag-screw.

Lag-screw—A flat-headed screw, used to attach lags to band-drums, etc. Also see Lag-bolt.

Laminated—Split up into thin plates or layers; consisting of plates, scales or layers, one over another, as the core of an electric armature or a vehicle body of laminated wood.

Lamination—The state of being laminated, that is, arranged in thin layers or plates.

Lamps—A satisfactory motor lamp should meet the following requirements: It must give a powerful light, thrown well ahead; it must be able to withstand vibration and jolting without the light being put out or rendered unsteady. The ventilation must be sufficient to give the flame the necessary air supply, and yet not be blown out by head, side, or tail winds, or by the draught created by the car running at a fast speed. It must be capable of burning from four to six hours without attention, and should be as simple in construction as possible.

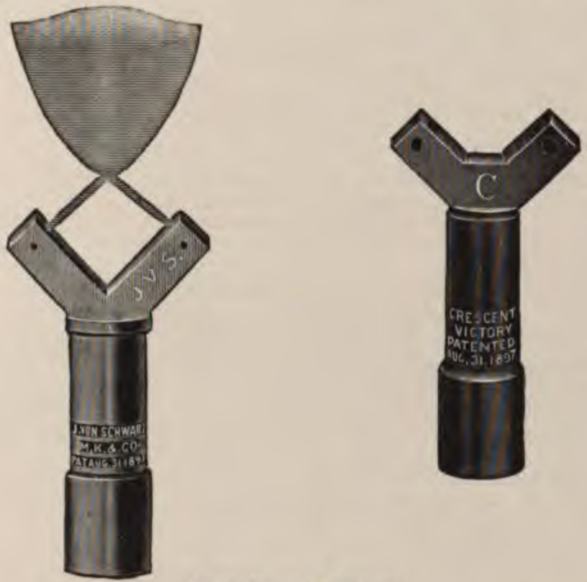


Correct Piping for Gas Lamps

There are three types of lamp in use upon motor cars—acetylene, oil, and electric.

Acetylene Lamps.

Acetylene lamps are specially constructed to burn acetylene gas, which is produced from calcium carbide, or acetylite, acetyloid, or other special preparation of the first named. The lamp, as a rule, consists of two principal parts—the generator and the lamp proper. The generator is the part in which the gas is produced, and in self-contained lamps consists of the following parts: Water tank, carbide, gas and filter chambers, and a gas bag. The carbide, or preparation of carbide, is put into its chamber, and water from the tank is dropped upon it by one of several methods. Directly the water touches the carbide, the latter commences to decompose into lime, liberating at the same time a gas known as acetylene. This gas is collected in a reservoir, and by its natural pressure forces its way through the filter chamber, which is filled with cotton wool, horsehair, chemical slag, or similar material, which will arrest the carbon contained in the gas. From the filter the gas passes into the gas bag, which is made of rubber and generally placed in the back of the lamp. It serves to equalize the pressure to a certain extent. The water supply to the carbide is so arranged that when the pressure reaches a certain point the water is cut off, and thus no more gas is generated until the pressure falls, when water is again admitted.



Acetylene Burners.

The lamp proper consists of the burner, reflector, and lens. The burner is usually constructed of lava and has two very small holes opposite to one another and at an angle, so that the two streams of gas meet, and, when ignited, form a fishtail flame. The reflector is made of copper, heavily silver-plated and highly polished. In the best lamps it is frequently covered by glass. The lens is in the front part of the lamp, and serves to diffuse the light at a very broad angle, so as to light up a great width of the road. A single one of these lamps placed in front and at the center of the car is sufficient to light up the road for the driver. Two or more lamps are, however, generally fitted. Often the reflector has a parabolic curve so as to throw a large number of the rays of light straight forward. In some cases a shield is used behind the burner to cut off the reflected rays when driving in traffic, so as not to inconvenience other users of the road by the excessive glare. The shield can be operated by the driver.

One form of generator uses a drip feed of water to the carbide, with an ingenious arrangement for altering the head of water by means of the swelling of the carbide when wet.

There is another type of acetylene lamp which is now more generally used. This is the lamp with separate generator, which often includes a rubber bag to regulate the pressure. The generators are stored away in any convenient receptacle on the car, and rubber pipes convey the gas to the lamps. The adoption of this system enables one to use a much lighter and more convenient form of lamp, and does not overweight the front of the car. In case of collision, too, which often results in the lamps being injured, the damage is not so expensive to make good, as the container does not suffer. An excellent combination is to have a headlight or searchlight in the center of the car in front, and two small lamps with separate generators on the dashboard. Under ordinary circumstances these small lamps would prove sufficient. See Searchlight.

Cylinders of condensed gas are now on the market, which obviate the necessity of carrying a generator.

Tail Lamps.

The law in many places requires a tail lamp to be carried, so arranged as to throw a white light on the number plate fitted to the back of the car, and sometimes, also, to exhibit a red light visible from behind. A small acetylene lamp or an electric lamp is best for this purpose, as such lamps are not liable to jolt out.

Oil Lamps.

These are usually constructed to burn kerosene or coal-oil. They throw a poor light, but give very little trouble, it only being necessary to keep the reservoir filled with oil and the wick free from the carbon which forms after some hours' burning. The lamp lights up at once, and if properly constructed will remain alight through a heavy wind storm. In price they are not nearly so costly as the acetylene variety. Red tail-light lamps are also constructed to burn kerosene. Oil lamps are, however, liable to jolt out, and for this reason many recommend the use of a small acetylene lamp of the bicycle variety. Another advantage of the acetylene lamp is that the brilliant light thrown to the side of the road enables the driver to tell at once if his light is failing for want of carbide.

Electric Lamps.

Lighting from small incandescent lamps of low voltage is becoming very popular since the introduction of the magneto, as batteries can be carried to furnish current for such lamps, and in case of failure of the magneto they can be used for a spare ignition. For lighting tail lamps a voltage of 4 or 6 volts is sufficient, and for side or head lamps from 8 volts to 20 should be provided. As each cell of a storage battery only gives two volts, it is necessary to have more cells as the voltage is increased, but a very good light can be obtained from 8 cells giving 16 volts. These small lamps consume about one ampere of current, so that the capacity for lighting a certain number of hours with one charge can be calculated.

A new form of incandescent lamp made with an osmium filament has also greatly increased the practicability of electric lighting on cars, as these lamps have much longer filaments for the same voltage, and it is possible to obtain an excellent light from 8 volt bulbs. In some cases, though rarely, electric lamps are driven by dynamos run by the engine of the car. In this case, of course, a battery is arranged to supply the lamps, and to be kept charged by the dynamo; otherwise the lamps will go out when the engine stops.

From the point of view of safety, cleanliness, and convenience, the electric lamp has much to recommend it, and where battery charging is an easy matter, it can be adopted with satisfaction.

Lamps should and in many localities must be alight between one hour after sunset and one hour before sunrise.

The care of lamps is dealt with under Repairs and Adjustments; also see Accessories: Their Use and Repair.

Care in Night Driving.

As cyclists and most vehicles show no rear light at night, great care must be used to avoid running them down from behind. Generally one can see a faint gleam of light on the road; but unless carefully looked for it may easily escape notice. Horses and cattle, of course, show no light at all, and take plenty of watching for in consequence.

In meeting vehicles at night, do not be in too much of a hurry to resume the center of the road. Sometimes a wagon carrying lights is followed by one or more without illumination, and these latter are very liable to be crashed into. Motorists will always do well to use lamps which will not only serve as a signal to other vehicles, but will give enough light to show up the road for a long distance ahead. In fact, one should never drive so fast at any time that one cannot pull up well within the stretch illuminated by the lamps.

Cracking of Lamp Glasses.

When obtaining an acetylene headlight or kerosene side lights for use on motor cars, the buyer should always see that the front lens can be renewed readily in case of breakage. When the lens or a plain glass front is fitted in solidly, the heat from the burner so acts on the lamp body and the glass that if the latter is not spring fitted the chances are that it will crack; also the vibration may in any case crack it. The glass can be immediately renewed without returning the whole lamp to the manufacturer, if a split spring ring is fitted to

The "Britelite" Trouble Lamp.—American Enamel Co.

Studebaker Touring Car.

Studebaker Electric.

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hold it in place; the ring also allows of any expansion due to heat. On many occasions when a glass has been found cracked the excuse has been given that the glass has been knocked by some hard substance, whereas in the majority of cases the failure has been due to the causes given above.

If the heat given off by an acetylene flame in a headlight is found to crack the lamp glass, cut a piece of sheet mica to match the glass and cement it to the inside of the lens with Canada balsam. This, while effectually curing the trouble, will not appreciably affect the quality of the light.

Care of Acetylene Lamps.

Many automobilists have difficulty in keeping their acetylene lamps in good going order. The trouble usually lies in the lamp not being kept properly cleaned, or through being improperly charged. To keep the lamp at its best light-giving powers, and to give the least trouble, clean water should be put into a tank every time the charge is renewed, and not merely fresh water added to that already contained in the tank. Fresh carbide should be put into the generator, and should there be any remains of the previous charge this should be removed and carefully cleaned of all the free lime which may have accumulated around it. The deposit left by the dissolution of the carbide should be thoroughly cleaned out, the generator being washed and dried before the new carbide is put in. The burner should be kept perfectly clean, which can be very easily done by dipping it in lye, and then washing it in alcohol or gasolene. The small holes are best kept free by using the wire prickers which are usually supplied with the lamps, and then by clearing out any of the carbon deposit by attaching it to the tube of a bicycle tire-pump and blowing through it.

If in probing the tiny holes in an acetylene burner with the fine steel probes supplied by many makers one unfortunately breaks a piece off in the hole in such a way that it cannot be withdrawn or shaken out, it does not follow necessarily that the burner is ruined. Try expulsion with the tire pump;

but if this does not avail, it is possible to get rid of the stricture-forming fragment by putting the burner into a solution of hydrochloric acid—a teaspoonful of acid to a large wine-glassful of water. The solution should be warmed while the burner is immersed therein, when the steel will be attacked by the acid, and practically dissolved. Keep the burner in the solution for at least an hour; then rinse it well in water, to which a pinch of ordinary washing soda has been added. This will neutralize the acid which may have penetrated the pores of the burner.

Lamp Covers.

It is a wonder that head lamp covers are not more often used. A couple of really strong covers made from good waterproof fabric save a great deal of trouble. They not only keep the acetylene lamps free from mud, and from being tarnished by rain, and so save a great deal of cleaning, but they keep the dust out of the lamps and out of the burners, so that the lamps are always in the best possible condition for use when required. The ordinary kerosene side lights do not matter as a rule, because they are high up, and comparatively well out of the dust and mud; but the gas lamps are more or less bombarded by the dirt which comes off the front wheels, and they are not only made very dirty outside, but a lot of dust and mud finds its way inside. It is also a good plan to have a hood for the back lamp, because this is the very dustiest place on the car; and after a long day's ride on dusty roads, it is often found impossible to get the lamp to burn, because it is so hopelessly choked up with dust.

If one comes to think of it, it is ridiculous to expose the back lamp to so much dust and dirt. It is usually only wanted for a very short distance, a very small proportion of the total distance covered by the car; but when it is wanted, it is wanted badly, and it is only common sense to take suitable precautions to keep it in good trim for use. There is nothing to prevent its being carried in the car until wanted.

Temporary Rear Lights.

By including in one's outfit a suitable form of four-volt electric lamp, such as is used by many for testing batteries, a very satisfactory temporary light may be rigged up in case of failure on the part of the regular lamp. The majority of the test lamps sold are suitable, and only require the protecting box or cover to be unscrewed from the base. When this is removed it leaves the lamp exposed, but rigidly attached to its base or holder and the wires. Most of the wires are not sufficiently long for the purpose in view, but it is not a difficult thing to carry a length of twin wire and to connect it up to the other wires. The electric lamp being introduced into the body of the rear lamp with the wire passed through the top or any other suitable opening, it should be tied or wedged up to prevent it being broken by swinging about. The free ends of the wire can be connected up to the spare battery, or, if not required for a long period, it may be coupled to the battery serving the ignition coil. A two-volt lamp is better if the car is provided with but one battery. This, of course, consumes less current, and yet gives sufficient light for the purpose in most cases. Candles have been used with good results where trouble was caused through the wick shaking down or refusing to allow the oil to flow. Any tinsmith can make a suitable fitting to slip into the lamp for this purpose.

Lamp, Acetylene—See under Lamps above.

In acetylene lamps the gas is generated by the application of water to calcium carbide. The combined lamps and generators are very heavy, and put a severe strain on the brackets carrying them. A separate generator is to be preferred on this account, and especially where there are two lamps, as they can both be supplied from the one source. A good supply of carbide should be carried on the car, in view of possible night repairs; and one or two spare burners, in case the one in use should become choked. As acetylene lamps give an exceedingly bright light, it is well to use hoods or other devices for screening the glare, as this is liable to frighten horses and temporarily blind drivers meeting it.

Lamp, Acetylene, Explosion on—See under Explosion.

Lamp Bracket—The bracket bolted to the car which receives a lamp.

Lamp, Dome—A form of electric lamp used for interior illumination in closed cars; so called from the shape of the globe.

Lamp, Davy—The safety lamp inverted for the protection of coal miners, by Sir Humphrey Davy. It consists of a metallic receptacle for the oil, and a wire-gauge cylinder about 1½ inches in diameter and 8 inches high. The gauge prevents the flame communicating to gas outside the cylinder.

Lamp, Electric—See under Lamps above.

Lamp, Gauge—An electric light used to illuminate indicators, gauges, etc., on automobiles.

Lamp Ignition—See under Ignition.

Lamp Iron—A metallic socket or holder to receive a lamp. See Lamp Bracket.

Lamp, Soldering—A blow-torch used in soldering.

Lamp, Spirit—Any form of lamp for burning alcohol.

Lamps, Charging from—See under Battery.

Lamps, Cleanliness of—See under Cleaning.

Land—The smooth part of any surface which is grooved or marked with indentations. The smooth uncut part of the face plate of a slide-valve.

Landau—A carriage body having two seats facing each other and a top in two sections which may be opened and thrown back. So named from Landau in Germany, where first made.

Landaulet—Originally a small landau or one with only one seat. Modern automobiles with landaulet body usually seat four inside.

The following are the body specifications for a typical landaulet, having two folding seats in front of the fixed seat:

Doors: The side doors are extra wide, giving convenient entrance and exit, and are equipped with full sized coach locks

with lever handles; also extra locks to prevent the doors from being opened, keys being furnished for the same. Limit straps.

Windows: Beveled plate-glass windows in doors and sides with silk curtains on spring rollers. The window frame in the partition and the swinging glass screen placed in front of the driver may be swung up and secured to roof. Other windows drop. Divided storm curtains are placed in front and can be rolled up and fastened in place by straps.

Appointments: Electric dome light on roof inside. Speaking tube. Two movable foot cushions. Two folding seats face the rear seat and when not in use fold up against the partition and are covered and concealed by upholstered flaps. Toilet case with contents, including clock.

Upholstery: The outside seats are upholstered in hand-buffed leather; the seats inside, the roof and the flap covering the folding seats are upholstered in morocco tufted leather or broadcloth.

Lap—The part of one body which lies on and covers part of another. In a steam engine, the distance the slide-valve moves to or from the cylinder after the closing of the steam passage. In races, one circuit of the track along which the competitors have to go a certain number of times in order to complete a specified distance.

Lap-joint—A joint in which the edge of one of the component parts overlaps the other.

Lapstreak, Lapstrake—Said of a boat constructed of boards overlapping one another at the edges; also called clinker-built or clincher-built.

Lap Welding—A welding or weld made by lapping one piece of metal over another before hammering; distinguished from butt welding, or end-to-end welding.

Larboard—The port side of a vessel, or the left-hand side as a person on deck faces toward the bow.

Lateral Thrust—On many of the driving or transmission shafts in motor vehicles end thrust is set up; in the engine shaft due to the engaging or disengaging of the clutch, and in the other shafts, such as the torsion shafts and propeller shafts, due to the bevel wheels tending to crowd away from each other. It is generally taken up by a ball thrust bearing. See Bearings.

Lathe—A machine by which an article may be shaped or polished by being rotated before a tool pressed against its surface.

Lathe, Choice of a—See Tools, Spare Parts and Accessories.

Lava—Properly the mineral matter ejected from a volcano in a molten state, which subsequently cools and hardens. Often applied to a form of talc or soapstone used for insulation purposes, for gas burners, etc.

Laws and Ordinances—See Motor Car Law.

Laying Up a Car—When a car is to be laid up for any length of time care should be taken to see that it is first properly prepared by a special course of treatment.

The first care should be to see that the engine is thoroughly cleaned in the manner prescribed under Care and Maintenance, Cleaning Motor and Machinery Parts, etc. Any repairs and adjustments that appear necessary can profitably be made at this time so that the car will come out in good shape after its period of rest or storage. Always remember that one cannot expect a car to come out in good running order unless it is in fit condition when laid away.

Transmission Gear.

The change speed gear should be washed out with kerosene in a similar manner to the engine. If the car is a direct driven one, the bevel gear case should be filled with grease, there being no necessity to clear this out, though it would do no harm if it were washed out with kerosene and fresh grease put in. The change speed gear box lid should be removed, or probably in many instances it would be better to remove the top half of the gear box completely so as to expose the gear wheels contained therein, for inspection purposes. The gear-shafts should be felt for slackness, and if any motion except a slight movement endwise is noticed, they had better be seen to at once by the repair man. If the gears are found to be in good order and require no attention, the gear-box should be filled up to the under side of the gearshaft with gear-box oil or lubricating oil and grease, about one-third of the latter to two-thirds of the former.

Connections and Chains.

All the pins, joints, and connections should be well oiled; in fact, it would be better to remove these, cleaning them thoroughly and replacing them, having previously given them a good coating of vaseline. The wheels should be jacked up and removed from their axles, these and the axle-boxes being cleaned out and well greased before replacing. When going round the car, attention should be given to the anchored ends of the springs, and the shackles on the free ends of these should also be well greased. These are some of the points which are particularly liable to be overlooked when going through the process of overhauling and cleaning. Where chain drive is employed, the chains should be removed from the sprockets and well cleaned in kerosene, after which they should be immersed in melted tallow and allowed to remain in this for several hours. Remove the chains, and hang them up to allow the superfluous grease to drain off.

The Clutch.

Special attention should be given to the clutch. This should be withdrawn as far as possible, and its surface well cleaned with gasolene, after which it should be given a good coating of neatsfoot or castor oil. Some have used successfully a mixture of one-half castor oil to one-half of glycerine. It is well to note that the application of clutch dressings is useless unless the clutch leather, where used, is in a condition to absorb some portion of the dressing applied. Thus it happens that a slipping clutch will soon attain so hard a surface that it cannot take up any of the moisture it needs so badly when any dressing is applied. An application of gasolene—assisted by a hard brush—will bring the clutch leather to a state in which it may be successfully treated. Look to the adjustment that it does not slip or grip too tightly. If the clutch be interconnected with the side brakes, pay particular attention to the adjustment here, as it requires very careful checking to act properly.

The Protection of Exposed Metallic Parts.

After having attended to the engine and gearing, the next thing is carefully to go over all the metallic parts of the frame and of the connecting rods used in conjunction with the steering gear, change speed gear, and the brakes. Where the paint has been scratched or hacked sufficiently to expose the metal, this should be rubbed bright with a piece of emery cloth and paint or air-drying enamel applied, giving it at least two coats of either. All plated or polished parts should be given a coating of pure vaseline after they have been thoroughly cleaned and polished. Pure vaseline, as obtained from the druggist, is specified as distinct from the commercial article, which is not so pure, containing as it does salts which are injurious to nickel or silver-plated parts, whereas the refined vaseline has no effect upon them. In the course of a few runs the greased bright parts will collect a certain amount of dirt, which, if necessary, should be very carefully removed with a piece of rag soaked in kerosene. The dirt should be scraped rather than rubbed off, as the rubbing is liable to cause scratches. A long, slow sweeping stroke of the kerosene rag takes up the dirt without using it as an abrasive material. This is a very important point, for scratched brass or plated work looks extremely bad. If the dust of many months be allowed to accumulate over the vaseline, it will do no harm, for it bears the same relation to the grease surfaces as the hair of a rabbit skin; one cannot remove the one without the other.

Lubricators.

All the lubricators should be drained of any oil which they may contain, and should be thoroughly washed out with kerosene or with gasoline. Where sight-feed lubricators are fitted, [illegible] which necessitate the using of lengths of copper pipe to convey the lubricant from its receptacle to the bearings, such pipes should be removed, and should have kerosene passed through them. For this purpose, a syringe is the best instrument to use, as the cleansing fluid can be passed through the tubes at a pressure which will insure any obstruction caused by the congealing of the oil, or by other causes, being swept away. If this is done and the pipes are reconnected, when the car is taken out again one will know that all that is necessary for good working of those parts is a fresh supply of lubricating oil.

Tire Treatment.

We now come to the question of tire treatment, and here it is somewhat difficult to advise, for there are variations in each and every make of tire. That is to say, there are some tires of one make which wear very much better than others, and these are always worth retreading if the fabric is good; others there are in which slices of rubber come away from the fabric wholesale, leaving it to be attacked by wet, and thereby ruining it for retreading purposes. The question as to when a tire needs repairing is one of sympathetic judgment. We have seen men cheerfully running tires upon whose treads there was scarcely an ounce of rubber left, and yet they talked of having them retreaded "when the rubber was all gone." Directly a bad cut in the rubber is observed, a rule should be made of having it attended to at the first opportunity. The cut should be washed out with water to remove dirt, and then carefully dried. Gasolene should then be wiped or brushed into the cut to further clean the surfaces and prepare them for the coating of rubber solution, which should be next applied. After the solution has been left for about ten minutes or a little more, the cut may be filled up with one of the many preparations which are now sold for the purpose. Failure in a repair is invariably traceable to insufficient cleansing or experimental treatment. Any cuts which are found in the covers should be dealt with on the lines indicated above. If one has any suspicion that any particular tire is in such condition that it may at any time become a "lame duck," have it off; it saves hours (possibly on the roadside) at a later date. This is also a good opportunity to repair any punctured inner tubes which may be on hand. For this purpose there are handy vulcanizers to be obtained if one wishes to do the work oneself.

Laying up for the Winter.

Having now indicated the general lines of treatment to pursue in preparing a car for winter use, we must consider the owner who, for special reasons, is compelled to lay up his car during the whole of the winter. The car to be laid up should be treated on the general lines already laid down, but some further attention is also necessary. When the car is brought in after its final run, the first thing to be done is to remove the cushions, aprons, lamps, horn, and all the tools and spare parts. The battery should be taken from its box, and it would be advisable to remove the coil and all the wires connected with the electrical ignition apparatus. When doing this, a rough sketch should be made showing the method of wiring, as when these parts have to be replaced it is as well to have a definite guide at hand, for in the interval between the putting away and bringing out the car it is the easiest thing in the world to forget the terminals to which particular wires should be connected.

Care of the Engine.

As to the engine, some additional attention is needed, particularly with regard to the interior of the cylinders. These should be well washed out with kerosene followed by a little gasolene. This treatment dissolves any oil which may be on the cylinder walls or piston, and which may cause them to stick, and it prevents the oxidation of the oil if it is allowed to remain. As to painting the engine over, which is often advisable, some owners inquire if it will be necessary to clean off the paint before running the engine again, and if so, they strongly object to following this course. It would of course, be necessary to remove the protecting coating, otherwise when the engine began to get warm with running the paint would make itself particularly disagreeable. There is not much difficulty in removing such a covering if olive oil be used, as the olive oil never sets hard, and is therefore readily attacked by turpentine or gasolene. If the engine is not so covered, it may present a lamentable spectacle after a few weeks' standing. If not painted the engine should receive a coating of vaseline. Particular attention should be paid to the exposed portions of the valve stems, as should they become at all rusty, they are liable to stick in their guides and cause trouble. These should in any case be well coated with vaseline. As to the remainder of the car, it should be treated on the lines already laid down, with one or two exceptions, which we will proceed to deal with.

Battery Treatment.

The battery, when battery ignition is used, forms the principal object for attention among those parts which have been removed from a car, and great care will have to be taken with this for its proper preservation. It should be tested, and if found to be below its full voltage it should be recharged until this voltage is attained. The acid should now be poured out from the cells of a wet battery, which should be washed out with clean rain water two or three times so as to remove all the acid, and they should afterwards be filled up with pure clean rain water to a point the height of a quarter of an inch above the top of the plates. The rubber stoppers should now be replaced. While washing out the cells, the terminals also should be carefully washed to free them from all traces of acid. They should be wiped dry, and given a coat of pure vaseline as a further protection against their corrosion.

As many cells are filled with a semi-solid electrolyte, it is impossible to subject such to the above treatment, and as the acid cannot be removed from the cell, there is only one course of satisfactory treatment open, and that is to have the batteries recharged every six weeks at least. In the meantime, a small four-volt lamp should be connected in the circuit, and should occasionally be allowed to remain lighted for a period of, say, half an hour, so as to enable the battery to discharge itself to a slight extent. This helps to keep the plates in much better order than the mere recharging at stated intervals without any discharge having taken place.

Dry batteries can be dismissed in a few words. As nothing can be done to assist them in retaining their energy, it is as well to take advantage, if possible, of what current they are still capable of giving off. The cells may be used to energize electric bells, or they may be used for a glow lamp or some such purpose.

The Coil.

The induction coil requires but little attention. It should be put away in a dry place, and out of all danger of being subjected to high temperatures. For instance, it should not be put in a cupboard against that side of the wall where the chimney is likely to give off more than a medium temperature. It will thus be seen that the only requirements are to protect the coil from damp and from excessive heat. The reason for this is that paraffin wax is often used as an insulating material, and if this substance becomes sufficiently heated to melt, in many coils the insulation would be entirely broken down, on account of there not being sufficient non-conducting material on the wires. So that if this were to happen such coils would be absolutely ruined. Obviously, therefore, cold, so long as the atmosphere is dry, does not injuriously affect the coil.

Laying up Tires.

The tires need very special attention. They should be removed from the wheels, the air tubes carefully examined and tested, and if found to be in good condition they should be treated with a liberal supply of French chalk, and put into a bag or box, and stowed away, preferably in a dark room where an even medium temperature obtains. The covers themselves should be very carefully examined, and all cuts, whether large or small, should be treated in the manner already described. If this is not to the liking or beyond the capabilities of the owner, the tires might be sent to the manufacturers for general overhauling and repairs. This would really be the most satisfactory procedure. For the storage of the outer covers of the tires, the same conditions apply to the inner tubes. As their bulk is much greater than that of the inner tubes, the most handy method of protecting them for storage is to bandage them round with strips of canvas. An owner once had occasion to lay by a set of motor car tires, and instead of using French chalk for the outer covers, he used flowers of sulphur in a very liberal manner. After the tires had lain by for some four months or so, they were brought out, and looked as fresh and as good as ever. Not only so, but they showed no signs whatever of hardening or cracking, and retained their elasticity to the fullest degree. This was probably due to the fact that sulphur is the principal component used in the vulcanization of indiarubber. It is noticeable, as a general rule, that in the course of time the sulphur exudes from the rubber, leaving it in a very spongy form, thus allowing air to enter. This hardens the material, so that it eventually breaks up into small patches. The owner aforesaid tried the sulphur, therefore, as a matter of experiment, on the theory that sulphur thus applied to the outside of the covers would prevent that which was contained in the substance of the rubber itself from working out. He was pleased to note that his theory was borne out by practice. If it is not convenient to remove the tires from the wheels, the car should be jacked up and packing put underneath the axles, so that the wheels may be kept well off the ground.

Lamps.

Lamps, whether of the oil or acetylene type, should be thoroughly well cleaned and polished, wrapped in cloths, and stored in a dry place. Particular care should be taken to cleanse thoroughly the carbide container of acetylene lamps of all deposit, and to dry the interior of the vessel carefully before putting it away. If any carbide is allowed to remain in the container for any length of time it will form such a hard and solid mass as to endanger the container when it is removed by forcible means at a later stage. All oil and wicks should be removed from the vessels of oil lamps, and as a further precaution against the action of stale oil at a later period, they may be washed with a strong solution of hot soda and water, afterwards being carefully wiped out, or if a cloth cannot be inserted into the oil well, they should be dried by evaporation.

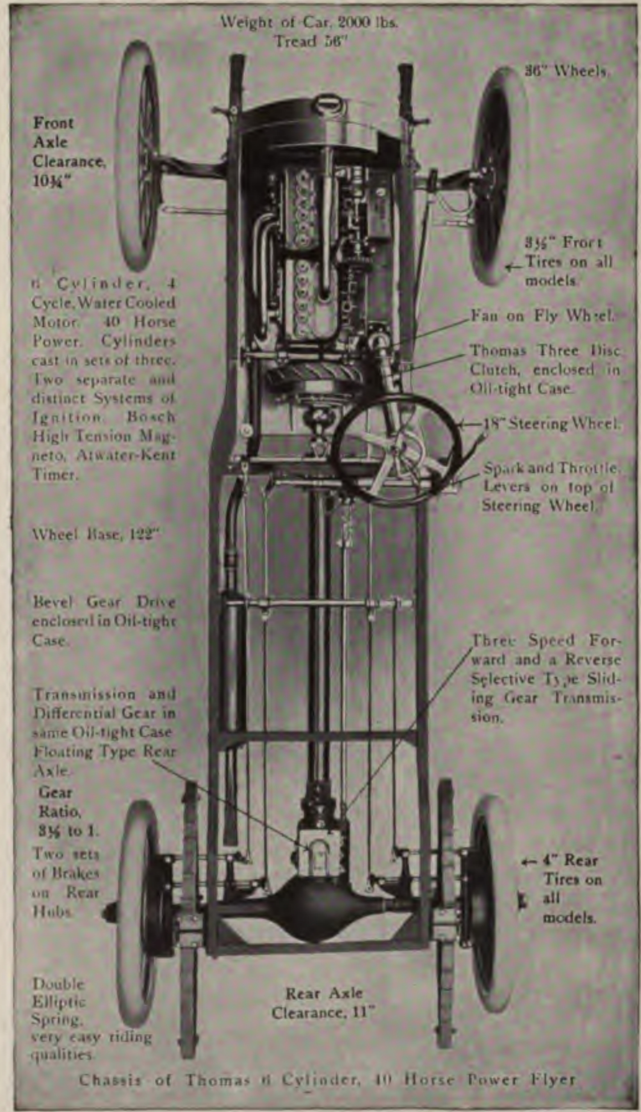
The horn which should have been removed at the same time as the aforementioned parts, should be cleaned and put away with the lamps.

A Covering for the Car.

Having now taken all the needful precautions for the protection of the car in detail, we next have to consider the vehicle as a whole. Even in the very best of garages, it is well to cover the whole of the vehicle, including the bonnet, with a light sheet, the edges of which are provided with tapes to enable it to be tied down into position over the car. Such vehicles as are provided with hoods or canopies present some little difficulty in this way, owing to the immense size of sheet which would be required to cover the car as a whole. Except for the really efficient protection of such cars as are so fitted, two sheets would be necessary, one of which would cover the body completely, slots being cut in the edges of this sheet at suitable points, so that the rods supporting the canopy would not interfere with the complete protection of the carriage body. If it is thought absolutely necessary to protect the canopy by reason of its being fitted with expensive curtains, a second sheet should be thrown over this, allowing it to hang down to a sufficient extent to meet the sheet which is placed over the car. Leather hoods should not be allowed to remain for any long period in a folded-up position, for however good the leather may be, and whatever means are taken to provide for its protection and the retention of its suppleness, it will dry and crack where sharp bends occur in it. For this reason it is well, if possible, to let the hood remain open during such time as the car is standing in the garage.

Lay-shaft—An intermediate or secondary shaft. See Shafts.

Lead—A soft bluish-white metal having specific gravity of


Weight of Car, 2000 lbs.
Tread 56"
36" Wheels.
Front Axle Clearance, 10¾"
3½" Front Tires on all models.
6 Cylinder, 4 Cycle, Water Cooled Motor. 40 Horse Power. Cylinders cast in sets of three. Two separate and distinct Systems of Ignition. Bosch High Tension Magneto, Atwater-Kent Timer.
Fan on Fly Wheel.
Thomas Three Disc Clutch, enclosed in Oil-tight Case.
18" Steering Wheel.
Spark and Throttle Levers on top of Steering Wheel.
Wheel Base, 122"
Bevel Gear Drive enclosed in Oil-tight Case.
Three Speed Forward and a Reverse Selective Type Sliding Gear Transmission.
Transmission and Differential Gear in same Oil-tight Case Floating Type Rear Axle.
Gear Ratio, 3½ to 1.
Two sets of Brakes on Rear Hubs.
4" Rear Tires on all models.
Double Elliptic Spring, very easy riding qualities.
Rear Axle Clearance, 11"
Chassis of Thomas 6 Cylinder, 40 Horse Power Flyer

The 6-40 Thomas Flyer Chassis.

11.36; used in storage batteries to carry the active material forming plates.

Peroxide of Lead: This substance when mixed with sulphuric acid, is used to coat battery plates. See Battery.

Red Lead: See Packing.

White Lead: See Packing.

Lead (pronounced "leed")—A term used to describe a wire carrying an electric current, or a small tube conveying lubricant.

Also used to denote the position of the piston before firing occurs. See Timing.

In a steam engine, the width of opening of a steam port.

In electricity, the angular distance between the contact points of the brushes of a dynamo and the line bisecting the "field."

Lead, Black—Graphite or plumbago.

Lead, Ignition—See Ignition Lead.

Lead, Kremnitz—Same as White Lead.

Lead, Red—A vivid red oxid of lead, $Pb_3 O_4$, used as a pigment. When mixed with mastic and linseed oil it is used as a cement for the flanges of steam-pipes, etc.

Lead, White—A pigment containing about three parts of lead carbonate to one part of hydrated lead oxid.

Leader—The driving wheel in gearing. Also a conducting pipe.

Lead-line—A line used in taking soundings, having marks at intervals for noting depths of water.

Lead Screw—The main screw of a lathe, which gives the feed motion to the slide-rest.

Leaf—Anything resembling the leaf of a tree, etc., as in being flat and broad, or in being flexible and movable attachment or addition to something else; a division or plate of a car spring, etc. Also a pinion tooth.

Leaf or Leaves Broken, Spring—See Miscellaneous Roadside Repairs.

Leaf Chain—A chain having flat links called leaves.

Leaf Spring—A motor car spring constructed of curved steel plates or leaves; a carriage spring. See Springs.

Leaf Valve—A valve hinged or pivoted at the side, as in a pumping engine; a clack or flap valve.

Leakage of Gasolene—See under Driving.

Leakage Through Piston Rings—See Piston Ring Vagaries.

Leak at Gasket—See under Loss of Power.

Leak in Crank Case—See under Useful Information.

Leaking Joints—See Repairs and Adjustments.

Leaking Patches—See Care of a Car on Tour.

Leaks—These may be classed under three heads: those which are dangerous: those which affect the power of the engine; and those which are only trivial.

Gasolene—Any leak in the gasolene supply system must be classed as dangerous, as the vapor from the escaping spirit is carried into the air and may reach a naked light, in which case it acts like a train of powder, leading the flame back to the starting point, and possibly setting the car on fire. All pipes, connections, tanks, etc., carrying gasolene should be carefully examined periodically, to see that there is no escape. It is quite safe to use a soldering iron on a pipe or tank containing gasolene, as the heat required to melt the solder is not sufficient to ignite the vapor, but no lamp or naked light must be brought near, nor should a blow lamp be used on a vessel which has contained gasolene without first making sure that it has been thoroughly cleansed from all spirit and vapor. Gasolene has the effect of ruining rubber, so that rubber piping should only be used as a very temporary repair job. Leather washers should be used in most cases where washers are necessary, and where leather is unsuitable lead is preferable, especially in or near the carbureter.

Water Leaks—Leaks in the water circulating system, if internal—that is, if there is an escape of water into the cylinder from a defective joint in the head or through porosity of the metal—will greatly affect the power of the engine, if they do not entirely prevent its working. See Water Circulation, under Repairs and Adjustments.

Pressure Leaks—In the case of a pressure feed carbureter a leak between the exhaust pipe and the tank, either in the pipes, joints, or valves, will prevent sufficient pressure being maintained in the tank to properly feed the carbureter.

Any leak of compression, either through the valves (inlet and exhaust), or through the piston rings or sparking plugs, will result in a loss of power, and, if excessive, prevent the engine working at all. See Bad Compression, under Repairs and Adjustments. Loss of pressure in the oil reservoir, where this is pressure fed, is a matter that should be rectified at once, or the lack of lubricant may cause serious damage to the bearings and cylinders of the engine.

By trivial leaks are meant small droppings of oil from the gear-case, and water from the pump, or from some part of the circulating system, which can be attended to at one's convenience.

Some of the above remarks apply also to steam cars, in which the boiler is the chief part requiring attention, as even small leaks from the bottom, though not dangerous, are apt to increase unless stanched, and, in any case, the stream of water corrodes the burners.

Leaks, A Hint for Stopping—See For Stopping Leaks, under Driving.

Leaks, Gasolene—See Miscellaneous Roadside Repairs; also under Gasolene.

Leaks in Water System—See under Circulation; also Water Circulation, under Repairs and Adjustments.

Leaky Radiators, Repairing—See under Circulation.

Learning to Change Gear—See under Driving.

Learning to Drive—See Driving.

Leather—The skin or hide of an animal dressed and prepared for use. In motor cars, leather is used for a variety of purposes, besides upholstery work, such as facing clutches, making belts, washers, packing, etc., and also in tire making. See Clutch; Tires.

Leather, American—Cloth varnished or enameled in imitation of leather; used in upholstery.

Leather, Artificial—A preparation of rubber and leather used for tire treads.

Leather, Chamois—See under Chamois.

Leather, Chrome—Leather prepared by steeping the skin or hide in a solution of bichromate of potassa, which largely increases its tensile strength; used in tire making and for belting, etc.

Leather Clothing—See Clothing; Dress.

Leather, Enameled, Care of—See under Cleaning.

Leather, Oiled—Leather made or prepared by a process in which oil is a factor.

Leather, Rock—A white or gray colored variety of asbestos; also called mountain cork or rock cork, from its lightness and fibrous structure.

Leather Washer—A washer or small flat perforated disk of leather, placed under a nut or pivot-head, or at a bearing or joint to serve as a cushion or packing.

Leatherette—An imitation leather largely used in upholstering.

Lee—The side or quarter toward which the wind blows, as opposed to that from which it proceeds.

Leeward—Having the same direction as the wind; opposed to windward.

Left-Hand Screw—See Screws.

Leg—The water-leg of a steam boiler is a downward projection which often surrounds part of the furnace.

Length Over All—The extreme length of a motor car, including all protuberances in front and behind.

Lens (of Lamp)—A lens is used in headlamps to condense and direct the rays of light in a forward direction, instead of allowing them to be diffused. See Searchlight.

Letters on Coils—See under Ignition.

Letting-down—In metal working, the lowering of the temper of a spring of steel, a tool, etc., that has been flint-hardened. The temper is reduced by heating and is gauged by the color of the heated metal.

Lever—A bar turning on a support called the fulcrum, and contrived originally to lift heavy weights. Used in motor car construction to operate the brakes, gears, clutch, etc.

Air Inlet Lever—The lever which controls the opening through which air is drawn into the carbureter. See Carbureter.

Air Mixture Lever—This regulates the mixture of air and gas used in the engine. See Carbureter.

Brake Lever—The lever which operates the brake.

Change Speed Lever—See Change Speed Gear.

Clutch Lever—See Clutch.

Control Lever—Same as Hand Lever. Also applied to the lever which operates the controller of an electric car.

Hand Lever—A lever used by hand for operating the gears, brakes, throttle, ignition, etc. The French term "manette" is sometimes applied specifically to the throttle and ignition levers mounted on the steering wheel.

Ignition Lever—The lever controlling the timing of the electrical spark. See Ignition.

Rocking Lever—A lever which rocks on a central stud or pivot. Often used to operate valves on the top of cylinders.

Reversing Lever—The lever which operates the reverse gear.

Spark Lever—Same as Ignition Lever above.

Trip Lever—A lever which is lifted and then suddenly released by means of a trip or projection on another lever or rod. Used in low tension magneto contact breakers or igniters.

Throttle Lever—The hand lever by means of which the throttle is actuated. See Operating Mechanism.

Lever, Driving—The control lever of an electric automobile.

Lever, Quality—A lever for regulating the quality of the explosive mixture; used with surface carbureters, etc.

Lever, Quantity—A lever for regulating the quantity of mixture admitted to the engine; used with surface carbureters, etc.

Levers, Operating—See Operating Mechanism.

Lever, Starting—A lever for starting a motor.

Lever, Steering—A lever for operating the steering gear. See Steering Gear.

Lever, Timing—Same as Ignition or Spark Lever. See under Lever above.

Lever, Tire—A lever specially designed to facilitate the removal and replacement of tires. They are made of various shapes and sizes and are extremely useful if not indispensable to the motorist.

Lever, Toggle—A lever consisting of two rods hinged together by a toggle joint. See Joints.

Lever, Universal—A device securing rotary motion by the reciprocating action of a lever.

License—A certificate issued by a municipality to authorized drivers of motor cars; a legal permit of any kind.

Life—The period of duration of usefulness or efficiency of a machine or other structure.

Life of Motor Cars—The life of a motor car, like all other machines, depends so much on the use or abuse which it may receive that it is almost impossible to arrive at any definite figure.

The engine appears to suffer least of any part of the car; the body should last almost as long as an ordinary carriage, but the tires, gearing, chains, wheels, axles, and steering gear are the first parts to show wear.

Taking any car of a high grade made for ordinary road work, not racing, and on which a fair expenditure has been made each year to keep it in good order, there is no reason why the life of such a car should not reach ten to twelve years, and cover a mileage of from 50,000 to 100,000, according to the nature of the roads on which it is used and the way it is driven.

Lift—One of the steps in a cone-pulley; a hoisting apparatus.

Lifter—A short name for the exhaust valve lifter used frequently on motorcycle engines, but not much used on motor car engines. The plungers which lift the inlet and exhaust valves and which are operated on by the cams are sometimes termed lifters, the term really describing their function.

In a steam engine, the arm on a lifting-rod that raises the puppet valve.

In founding, a tool for dressing the mold; also a device to hold the sand together in lifting the cope.

Lifter, Exhaust Valve—See Lifter above.

Lifter, Valve—See Lifter.

Lifting Jack—A form of jack adapted for lifting. See Jack.

Lifting Rod—In a steam engine, a rod receiving motion from the rockshaft and imparting motion to the lifter of a puppet valve.

Lift Valve—See Valves.

Light and Warmth in Motor Car Houses—See under Care and Management.

Lights—See Lamps.

Limit of Elasticity—The amount of deformation or strain which, if applied to a body, is such that if it be increased the body will not completely return to its former state when released.

Limousine—A popular style of closed car body in which the front seats are partly open and the rear seats inclosed. The window or partition between front and rear seats is usually capable of being opened or removed at will, as by lowering into the body or swinging up against the roof.

Line—A cord or rope used for some special purpose, as a towline. The course in which anything moves or aims to move, as a line of travel. In machinery, the proper adjustment of parts in working order.

Linear Speed—Rate of progress or movement along a line.

Line of Action—A straight line in the direction of the action of a force.

Lines of Force—See Coil; Ignition.

Liner—In machinery, a thin piece inserted between parts to adjust them; a packing-piece. The lining inside the cylinder of a steam engine.

Link—A link is a connection between two movable members, nearly always used to couple the ends of two levers together, as in the link which couples the arms of the steering levers on motor cars. Roller chains are composed of a number of links which connect the pins on which the rollers of the chain revolve.

In linear measure 1 link =7.92 ins. or 8,000 links in a mile. This unit of measurement is chiefly used by surveyors.

Also a device used in steam engine practice to reverse the engine by altering the position of the slide valve with relation to the piston.

Link, Drag—The rod which connects the steering arms of a motor car. Also applied to the link in the device known as link-motion, or the reversing gear.

Link Motion—See Reversing Gear; also Steam Cars, under Motor Cars.

Link, Reversing—The link in a link-motion or reversing gear. See Reversing Gear.

Link, Steering—The link or rod which connects the steering arms connected with the front axle of an automobile.

Links, Extra Chain—See Adjustment of Chains, under Chain.

Link-work—A term sometimes applied to the various rods, levers and links connected with an engine slide-valve, sometimes to the coupling or connecting rods of wheels and cranks.

Linoleum—A floor-cloth made by mixing a preparation of linseed-oil with ground cork and pressing it upon canvas.

Liquid—A substance whose parts are capable of moving freely among themselves on the least pressure, and which therefore retains no fixed form; a fluid not aeriform.

Liquid Air—Just as the application of heat or the raising of temperature of a liquid causes it to vaporize and become a gas, as in the case of gasolene and other hydrocarbons, so by the abstraction of heat, or the reduction to an extremely low temperature, the opposite effect can be produced and a gas can be turned into a liquid. Air, which is a mechanical mixture of oxygen and nitrogen, can, by subjecting it to intense cold and a very high compression, be reduced to a liquid state. When in this compressed state it is capable of giving back nearly the same power as was expended in compressing and cooling it, during the process of again becoming a liquid. A considerable number of experiments, with a view to utilizing this remarkable property of liquid air and applying the energy from it, have been carried out, but so far the practical results have not been encouraging.

Liquid Fuel—Liquid fuels, used in engines for automobile propulsion, may be divided into three classes: Petroleum products, coal tar products and alcohols. The first class includes gasolene and kerosene, the second naphtha and the third denatured alcohol.

So far as it interests the automobilist the uses to which liquid fuel, as such, can be put are practically few, and it is really only in the steam car that it is available. Its advantages over solid fuel, such as coal, coke, or wood, lie in the compact space it occupies compared with the heat it is capable of generating, and also the adaptability with which it can be led from its place of storage to the point at which it is burnt, in exact quantities, at exact speeds, and without any manual handling.

In using liquid fuel in a steam boiler, two systems are adopted—one in which air is pumped in by the engine to supply the oxygen and to cause the spray, and the other in which steam is blown through a jet, bringing out with it the liquid fuel in the form of atomized spray.

Liquid Fuel Burners—The burners in which liquid fuel is burned are of two kinds, consisting of sprayers and vaporizers. The Bunsen burner is an example of the latter class. In the former class spray jets are used, which are practically the same as used in carbureters, but, of course, on a much larger scale. Another type of vaporizing burner consumes the fuel in the presence of air without previously mixing it with oxygen.

In order to vaporize the fuel before it enters the burner, it passes through a coil of thick copper pipes which encircle the flame; the gasolene thus becomes a rich gas long before it enters the spraying nozzle, and is there mixed with the requisite proportion of air to give the best composition. Around the burner is a pan, which, for purposes of starting the burner, can be partially filled with methylated spirit (alcohol). This when lighted starts the vaporizer, and the action of the burner then goes on automatically.

List—A selvage of wire or tin formed on the under edge of tin plates.

An inclination or careening to one side.

Liter or Litre—A measure of capacity containing 61.028 cubic inches or 1⅔ pints. See Metric System.

Literature of the Automobile—See Introduction to the Cyclopedia, Trade Papers, etc.

Litmus-Paper—Paper colored blue by litmus and used as a test for the presence of acids and alkalis; also used for pole-finding in battery testing. See Battery.

Litre—See Liter.

Little End—The end of the connecting rod of a motor which is attached to the piston. The end attached to the crankshaft is the "big end."

Live—Communicating motion, as a live axle; under pressure or imparting power, as live steam.

Live Axle—A driving axle. See under Axle.

Live Circuit—A circuit through which an electric current is passing.

Live Force—See under Force.

Live Steam—Steam under pressure or imparting power; steam fresh from the boilers. See Steam.

Live Wire—A wire forming part of a live circuit.

Load—The term as used in motor car parlance denotes two kinds of load—the load carried by the car and the load carried by the engine. The engine is said to have taken up its full load when it is giving out its highest power with the throttle open and the ignition fully advanced.

In electricity any resisting force, aside from internal friction, met by a motor.

Load, Too Heavy—See under Loss of Power.

Lock—The oblique position caused by the deviation of the fore axle from the line of direction of the rear wheels and the trend of the vehicle proper.

A cotter or key used to hold parts of a structure in position.

Lock, Air—See Air Lock.

Lock Nut—See Bolts and Nuts.

Lock, Steering—See Steering Gear.

Lockers—Because a car differs from a carriage in the enormous variety of uses to which it can be put, and as it is advantageous to carry upon a car a large number of articles which are not required on a horse vehicle, it is almost impossible to provide too much baggage space. Many modern cars are therefore well supplied with lockers, adding largely to their convenience and comfort, especially when touring. A rule that should be strictly followed in the use of the lockers, however, is to have "a place for everything and everything in its place."

Locking Devices—See Bolts and Nuts; Change Speed Gear.

Log—An apparatus for measuring the speed of a ship. An improved form is a piece of mechanism, towed astern of the ship, the distance traversed being indicated on a dial.

Log-line—A line or cord by which a ship's log is fastened to the stern; also the knotted line used in heaving the old form of log.

Longuemare Carbureter, The—See illustration and description under Carbureter.

Looking at Lever Quadrant—See under Driving.

Loose Bearing—See under Pounding and Knocking.

Loose Cam or Cam Shaft—See under Pounding and Knocking.

Loose Connecting Rod—See under Pounding and Knocking.

Loose Connection—See Misfiring, Causes and Treatment.

Loose Contacts—See Misfiring, Causes and Treatment.

Loose Contacts and Faulty Firing—See under Ignition.

Loose Crank Case—See under Pounding and Knocking.

Loose Cylinder—See under Pounding and Knocking.

Loose Flywheel—See under Pounding and Knocking.

Loose Magneto—See under Pounding and Knocking.

Loose Nuts or Bolts—See under Useful Information.

Loose Oiler Mechanism—See under Pounding and Knocking.

Loose Pulley—A pulley fitted loosely on a shaft near a fast pulley to receive and support the belt when thrown off to disconnect the shaft.

Loose Pump or Magneto Pin—See under Pounding and Knocking.

Loose Wrist Pin—See under Pounding and Knocking.

Lorry—A long wagon or truck, having a large flat platform set upon four small wheels.

Loss, Friction—See under Friction.

Loss of Compression—See under Compression; also Loss of Power.

Loss of Engine Power—See under Engines.

Loss of Power—In ordinary practice the loss of power in a gasolene motor develops rapidly; that is, within a few hours or at most a few days. It would require several years for a motor of modern design and manufacture to wear sufficiently to cause any appreciable falling off in effective work. It must be reasoned, then, that something has gone wrong, more or less suddenly, something that can ordinarily be detected by careful and patient search. This may take several hours, or even a day or two, and can be accomplished only by beginning at the most likely and most frequent cause and going all down the line—by the process of elimination, as in most cases of apparently serious difficulties with the gasolene motor.

Weak batteries, loss of compression and poor carbureter adjustment may be put down as the prime causes of loss of power. It is not difficult to determine the exact state of the ignition system; it is not difficult to adjust a carbureter; and it is not difficult to learn that the motor's compression has fallen off. It is, sometimes, difficult to ascertain the cause of the loss of compression.

It must be remembered, however, that the condition of one of these prime elements bears important relation to the other. For instance, a carbureter cannot be correctly adjusted unless the ignition system is right and the compression is somewhere near normal. Because of this it is essential that the ignition system be given attention first, followed by ascertaining that the compression is good and equal in all the cylinders.

Ignition.

(a) Weak Batteries—Test dry cells to show from 15 to 17 ampères on an ammeter, disregarding voltage. If the batteries show under 5 to 7 amperes, replace with new ones. Possibly only one cell will show depletion, in which case one new cell may effect a remedy, for a time at least. If there are two sets of batteries in the car they can be connected together in series—that is, all the cells connected as if there was but one set—and this will carry the car to a point where new batteries can be secured.

If a storage cell is used, test by connecting one end of a wire to one of the binding posts and snapping the other end across the other binding post. A large, snappy spark will indicate sufficient current; if it is an apparent weak spark, which can easily be determined, the battery needs recharging.

It is well to know that dry cells can be obtained at almost any telephone office in the country, so that under ordinary circumstances the motorist can run his car to one of these stations.

(b) Timer Slipped—This retards the ignition and usually causes overheating of the motor. The location of the timer in relation to the shaft to which it is attached should be marked, so as to be replaced easily. Also, the owner should know just where the spark lever should be on the quadrant when the piston is at the top of the compression stroke, and when contact on the timer is made. Sometimes the slipping may be found to have occurred at the connections between the hand lever and the timer. Look these over and if possible take up all slack, so as to make the movement of the timer through the spark lever positive.

(c) Plugs, Fouled or Short Circuited—Clean the plugs by immersing in gasolene and cutting the carbon deposits off with a knife. At the same time see that the points are 1/32-inch apart—no more, no less. Accumulated oil will cause a short circuit, as will carbon deposits or a cracked or chipped porcelain.

(d) Timer Gummed—Unless a timer is cleaned occasionally the old grease or oil will become gummed and saturated with metal filings caused by wear. This will cause a loss of some of the current and result in lag in the ignition; consequently a feeble impulse in one or more cylinders. Likewise a magneto must be kept clean in order to transmit current. A timer should be cleaned with gasolene and after dried of all the gasolene should be packed in hard grease, which not only remains as a lubricant but will tend to prevent dust from reaching the contact points.

(e) Poor Contact on Timer or Magneto—Where a timer is used, not infrequently the primary wire is not fitted with terminals to attach to the binding posts on the timer and the coil, the wires of several strands being attached direct. The movement of the timer in retarding and advancing the spark gradually breaks these little strands, until perhaps, only one or two remain—and one or two are not sufficient to carry current. In other cases the primary wires at the timer become oil-soaked and much current is lost. Poor contact at the timer, magneto, coil, battery, switch or plug will prevent a full flow of current and interrupt proper ignition of the gases in the cylinders.

(f) Oil-soaked Secondary Wires—Keep the wires leading to the plugs, in particular, and in fact any wires, free from oil and dirt, otherwise more or less of the circuit will be lost.

Loss of Compression.

(a) Valves Fouled; Not Seating—If the motor shows loss of compression, look first to the condition of the valves; probably they do not seat properly and closely and must be ground. (See Repairs and Adjustments.) Too much lubrication—possibly in combination with a poor mixture—causes this state of affairs. In cities, where speed is restricted and where the motorist is tempted to jog along with a low charge of gas and a high spark, the heat from the explosion is not sufficient to burn the excess of oil and the valves soon become coated, preventing them from seating and permitting the loss of compression.

(b) Nuts for Valve Cages not Tight—In valve-in-the-head motors, where cages are employed to form the valve seat and carry the valve and stem, the ring nut used to hold the cage down on its seat may not be set down tight, thus permitting compression to become weak. When the motor is hot, after two or three hours' use, set the nuts down. Treat valve nuts in T-head motors the same way. Where the threads have spread or become worn through constant removal, make a thin paste of litharge and glycerin and rub on the threads. Set the ring or nut down tight and let stand over night for the litharge to harden. It might be stated here that cracks, small holes, etc., may be thoroughly closed by the use of litharge in this form.

(c) Valve Spring Weak—Where a valve spring has become weakened, a temporary repair may be made by building up with iron washers that will fit over the valve stem and cover the spring, care being taken that the washers do not bind the valve stem or prevent its free working.

(d) Valve Spring Broken—If a valve spring breaks, place an iron washer between the pieces of spring—over the valve stem, of course—and a splendid emergency job will have been accomplished, one that will last indefinitely.

(e) Air Leak at Plug—This can be detected, usually, by placing the hand near the plug, when escaping air or gas can be felt. Or, pour a little oil around the plug while the motor is running and the leak will be immediately noticed by the oil bubbling. A leaky valve may be detected in the same manner. If the plug has a shoulder, a copper gasket can be inserted between the shoulder and the cylinder. If there is no shoulder, litharge and glycerine in a paste can be used on the threads to stop the leak.

(f) Rings Stuck—Over-lubrication will cause the oil to settle under the rings on the piston and eventually stick them to the piston, permitting the gas to escape past the rings. Inject a couple of teaspoonfuls of kerosene in each cylinder and permit it to stand over night. This will loosen the rings effectually. Better still, do not over-lubricate and the rings will not stick; too much lubrication will cause as much trouble—but not as much damage—as an insufficient supply.

(g) Broken Ring—If a ring breaks, its springiness is gone and the gases will escape past. The only remedy is a new ring A metallic knock sometimes will denote a broken ring.

(h) Ring Slots in Line—Where rings are not pinned in place, it is possible for the slots at the ends to "get in line," and under such circumstances gases will escape. If the rings are free they will right themselves. This is an unlikely trouble, however.

(i) Lack of Pushrod Clearance—Be sure there is clearance between the pushrods and valve stems, otherwise the valves will be held open slightly but sufficiently to cause loss of compression. This is apt to occur after valve grinding and the valve has been lowered a trifle through grinding. Give some clearance, as a temporary relief, but ascertain from the maker of the car the right amount to give proper valve lift.

(j) Lack of Lubrication—Oil fills the space between the cylinder walls and rings and piston. Lack of oil will permit some gas to escape.

(k) Leak at Gasket—Where cylinder heads are detachable, and where gaskets are used, a leak is very possible. A new gasket should be put in, using shellac on either side to cement it to the iron.

(l) Rocker Shaft Worn or Loose—In motors fitted with make-and-break ignition the rocker shaft may have become worn, or the rocker shaft barrel loosened, permitting loss of compression. Usually the remedy for the first named is either a new shaft or new mica insulation, while a copper gasket can be used over the barrel.

(m) Valve Stem Bent—A bent valve stem will prevent the valves from properly opening and closing by sticking and thus cause loss of compression. It can be heated and straightened for a temporary repair, but a new one is the surest remedy. If bent only slightly a little filing and finishing with fine emery cloth will prove effective for a temporary job. Where a valve stem has been straightened it is best to put it in a lathe to be trued up and then ground to fit the valve seat.

(n) Cylinders or Rings Out of True—In horizontal motors in particular, where one side of the piston rests on one side of the cylinder, these parts are liable to "wear oval." This is not apt to occur in a vertical motor. To effectually remedy this the cylinders must be reground and new pistons and rings fitted.

Mixture.

(a) Lack of Gasolene—Insufficient supply of gasolene at the spray nozzle—through clogging by sediment or dirt, or lack of pressure in pressure-feed systems—will cause a loss of power, particularly in hill-climbing or through heavy roads. Water in the gasolene will sometimes slightly restrict the flow, which should at all times be free. The remedy is a thorough cleaning of the fuel line.

(b) Surplus of Gasolene—Too much gasolene, through too great an opening of the needle valve of the carbureter will tend to choke the motor, particularly upon opening the throttle suddenly, and cause a sluggish-running motor. It will also heat the motor. If it is a case of too little or too much gasolene, readjust the carbureter, as per direction elsewhere.

(c) Float Level Too High—If the level of the gasolene in the carbureter is such as to be more than just below the top of the spray nozzle—about 1/32 to 1/16-inch in most carbureters—the mixture will be too heavy and cause sluggish running of the motor—if too low, the feed will be insufficient and will cause a loss of power at normal speeds and missing at high motor speeds. Where the float level is too low the valve shuts off too soon. With the gasolene level wrong it is impossible to properly adjust the carbureter, inasmuch as the tendency is to increase the fuel supply through opening the needle valve, which, while it may result in a correct mixture at some particular motor speed may be too rich at another. To correctly adjust a carbureter it is necessary to have the gasolene level right and to also have the ignition in good working order.

(d) Auxiliary Air Valve Spring Broken—Should the air valve spring in the carbureter be broken—which is not likely, however—the motor will be permitted to take in a surplus of air. This will in all probability be known by the motor missing if it keeps on running, which is doubtful. A case was known, however, where the air valve spring was entirely gone and still the motor would run, although it was hard to start and did not develop power. Should the air valve slip out of place or be broken the effect on the motor would be similar to that in the case of a broken spring.

Other Causes.

(a) Lack of Water Circulation—Insufficient supply of water in the cooling system, or poor water circulation, causing overheating or a tendency to overheat, will permit the cylinders and pistons to expand and to bind sufficiently to precipitate a loss of power. This will in all likelihood be preceded by a decided knocking, especially if the lubrication is not excessive.

(b) Intake Restricted—Where a car has been driven through dusty or muddy roads, the gradual accumulation of dirt in the intake pipe because of the absence of a pan under the motor, for instance, will settle in the pipe and cause a restriction that will act as a throttle. This can be remedied only by removing the pipe and cleaning by running a gasolene-soaked cloth through it.

(c) Throttle Connections Slipped—See that the connections between the throttle lever and the valve in the carbureter have not slipped and permitted the throttle to become partially closed. This is a not infrequent cause of the apparent lack of power.

(d) Muffler or Exhaust Pipe Clogged—A restricted muffler or exhaust pipe will pull down the power to a remarkable degree. If a cut-out is fitted to the exhaust system it will be easy to discover, with this open, if the motor seems to develop its full power. If it shows a falling off of power when closed the exhaust pipe and muffler should be cleaned. They should be taken down, soaked in kerosene and washed out with gasolene. Be sure, however, to see that the gasolene has been permitted to evaporate before attaching to the car and starting the motor, else a bad explosion may result. They should be permitted to stand all night and in a position so as to drain well.

(e) Too Heavy Load—If the car is loaded beyond its normal capacity it is not unlikely there will be a falling off in apparent power. Load the car to its normal capacity and see if there is any appreciable difference in the work of the motor.

(f) Bind on Running Gear or Transmission—Gummed axle bearings, dry differential or transmission, bent axle or steering knuckles, motor or transmission out of line, brakes binding or partially set, will cause loss of power. In searching for the cause it will be well to push the car along the floor to see if it runs freely, and that there is nothing materially wrong with the running gear. If it pushes hard it will be necessary to trace the trouble and remedy it.

(g) Soft Tires—Soft tires will make a car push extremely hard, either by hand or by motor power. Before trying the car to see how the running gear works, be sure the tires are pumped hard.

(h) Stiff Valve Springs—Where suction valves are used and a change in the springs has been made, possibly one that is too strong has been used. This will prevent a full charge of gas from entering the cylinders and thus the force of the explosion will be materially weakened. This cannot occur, however, unless some change has been made in the springs.

(i) Quality of Fuel—Fuel has much to do with the power that can be obtained from a gasolene motor, but if a carbureter is adjusted for certain grades the difference will hardly be perceptible. It is a mistake to suppose that a grade of gasolene of high test will give more power; as a matter of fact there are more heat units in a given quantity, in bulk, of the lower grades, but unless the carbureter is properly adjusted these heat units in the lower grades cannot be turned into working agents as readily as can those in the higher grades. With the lower grades of gasolene more heat is required to volatilize the gasolene than with the higher grades.

(j) Cold Motor—When a motor is extremely cold, particularly if the gasolene supply at the needle valve is cut down to a pretty fine point, the gasolene cannot be volatilized or made into gas and the actual result is a very light charge. In this case it is well, when the motor shows loss of power and misses, to run the motor with a later spark and a larger charge of gas until the motor has had an opportunity to become warm and to help volatilize the gasolene.

Also see under Repairs and Adjustments.

Loss of Power, Contributory Causes of—See under Driving.

Loss of Pressure—See Repairs and Adjustments.

Lost Motion—See under Pounding and Knocking.

Low Gear—See Change Speed Gear.

Low Pressure—Working with a low degree of steam pressure, as a low pressure engine.

Low Pressure Cylinder—See Cylinder.

Low Pressure Steam—See Steam.

Low Tension Ignition—See Ignition; Coil.

Low-Water Alarm—A device for indicating the low stage of water in a steam boiler.

Lubricants—Any natural or artificial materials, as oils and greases, used for lubrication or lessening friction.

Lubricating—See under Care and Maintenance and Lubrication below.

Lubricating Chains—See under Lubrication.

Lubricating Oil—Three conditions govern the nature of the lubricant used between moving metallic surfaces:

1. The weight or pressure tending to keep them in close contact.
2. The speed at which their surfaces move across each other.
3. The temperature at which they have to work.

Taking the first condition, it is obvious that where heavy pressures tend to keep the surfaces in contact an oil of such body or viscosity is required that it shall not be forced out from between the surfaces by the sheer pressure. On the other hand, where the pressure is very slight, a lubricant of much thinner consistency may, with advantage, be used.

The second condition, that of speed, is intimately connected with the third—temperature. The higher the speed the greater the friction set up in a given time, and the less the chance of dissipating the heat generated by the increasing friction, thus setting up a condition where the moving surfaces are extremely likely to become very hot. This necessitates that, while the lubricant should be fairly thick, it should be of such a nature that it will not be liable to become too thin for its purpose by reason of its increasing temperature.

The third condition—temperature—is one which becomes of the greatest importance to the motor engineer and the motorist, who have to lubricate some moving parts which are always at extremely high temperatures, and call for a lubricant which will retain a good body at these temperatures. That has been the great trouble with the makers of high-speed internal combustion motors, as it has been found very difficult to get a lubricant which will not run very thin in hot cylinders, or which will not become carbonized or burned up. Either of these defects renders a lubricant useless for lubricating the piston and cylinders.

Oil for Cylinders, Etc.

An oil for use in the cylinder should possess the following qualities: It should not boil until it reaches a high temperature, and it should at these high temperatures retain its viscosity. It should not be liable to be decomposed, or to liberate elements of an acid character which would exert an injurious action on the metal of the piston or on the walls of the cylinder.

In order to make provision for the reduction of body or thinning of the oil due to increase in temperature, two things are necessary:

First, that the body, at normal temperature, should be as great as the method of application will admit.

Second, that the system of application and the necessary pipes should be of such a description, and of such dimensions, as to admit of the use of oils of considerable body at normal temperatures.

In order to comply with the latter requirement, and use oils of a body which will provide the necessary lubricating properties, it has been found advisable to adopt some form of forced lubrication, and many of the best makers force the lubricant, by means of a constantly rotating pump, through direct conducting pipes, to each of the points where it has to be used. By the use of this method a considerably thicker oil may be got to the point of application than could be attained by a gravity feed through small pipes, especially in cold weather.

In the case of steam cars the difficulty is not by any means so pronounced, as the moisture left behind by the exhausting and condensing steam combines with the lubricant and effectually prevents carbonization, and itself assists very materially in the lubrication.

Oil for Gear and Bearings.

Shafts and gears as found in the transmission mechanism of motor vehicles require, of course, an oil which has not such extreme conditions to work under. Temperatures here are little above normal unless great carelessness in supply of lubricant is manifested, and generally a good mineral or animal oil of fair body can be used.

This applies to practically all the bearings throughout the car, including the gear shaft bearings, the universal joint and propeller shaft bearings and the bearings of the road wheels and axles, as well as the side or cam shaft of the engine, and the bearings of the pinions and gears which operate these and such other appliances as pumps, fans, and ignition contact makers and breakers. In the case of toothed gear wheels and pinions, it is generally now the practice to inclose them in an oil-tight gear box, and let them actually revolve in a bath of really thick oil. The very considerable friction which takes place in these gear wheels, however well designed, and the great pressures to which their small surfaces are exposed, make this the most efficient method of lubricating these parts, and the method exactly adapts itself in these circumstances to the use of an oil with heavy body, which, as we have seen,

is required where heavy pressure has to be transmitted. For this reason a heavy oil is used almost extensively for gear boxes and the inclosed differential gears of countershafts or live axles.

Lubrication—In all classes of mechanism where two parts slide upon or move against each other, friction is set up which acts as a resistance to the movement, causing heat, and often spoiling the surface in contact. The object of lubrication is to separate the surfaces from each other by a fluid which must be of a greasy nature so that the surfaces, instead of sliding upon each other, displace the particles or molecules of which the lubricant is composed. These molecules can be likened to so many infinitely small balls.

For various systems of lubrication in use, see Lubricators.

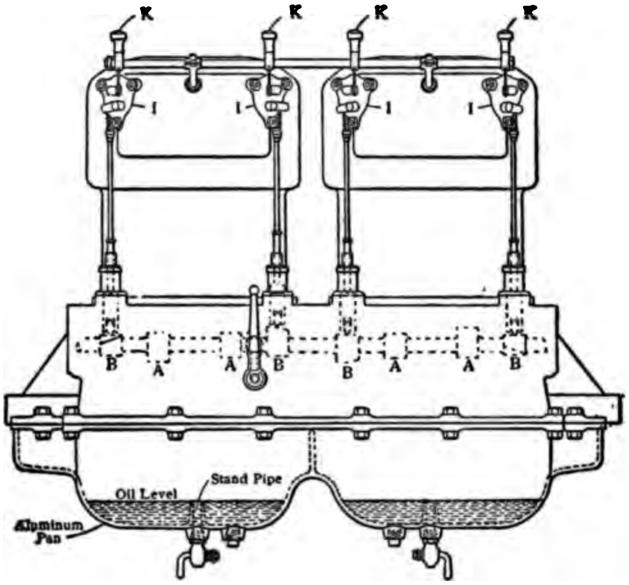
A Typical Modern System.

The accompanying illustration shows the method of lubrication employed in a typical motor of the most modern construction. The splash system is employed in this case (see Lubricators) and a description of the modus operandi is as follows:

An aluminum casting containing two compartments with an intervening partition, is bolted to the motor base and carries a quantity of oil which is splashed about to the various working parts of the motor, lubricating them continuously and thoroughly. The partition prevents the oil from rushing to the front of the motor when descending a hill or vice versa. By consulting the diagram it will be noted that the level of oil is obtained by means of a vertical standpipe; a pet-cock at the base of the standpipe is opened and the oil is slowly added until the level rises to the top of the standpipe, and when it begins to drip no more oil is added and the pet-cock is left open until the drip ceases, and when it does, the oil level is correct and the pet-cock may be closed.

As the motor is run and the oil is slowly used to lubricate the wearing parts, the loss must be made up in order that the level may be maintained constantly; to do this a mechanical lubricator is supplied which positively forces oil to the motor in the desired quantity through pipes of large diameter.

The lubricator is placed underneath the front floor board, just above the exhaust pipe, the heat of which keeps the oil at the proper consistency and fluidity necessary to obtain the best results. This arrangement makes it possible to replenish the lubricator conveniently, makes it accessible for adjustment, should this be required, and also prevents any spattering of oil on the occupants of the car.



Section of Motor, showing method of lubrication

K K K K.	**Cut-out switches**
I I I I.	**Igniters**
B B B B.	**Igniter cams**
A A A A	**Valve cams**

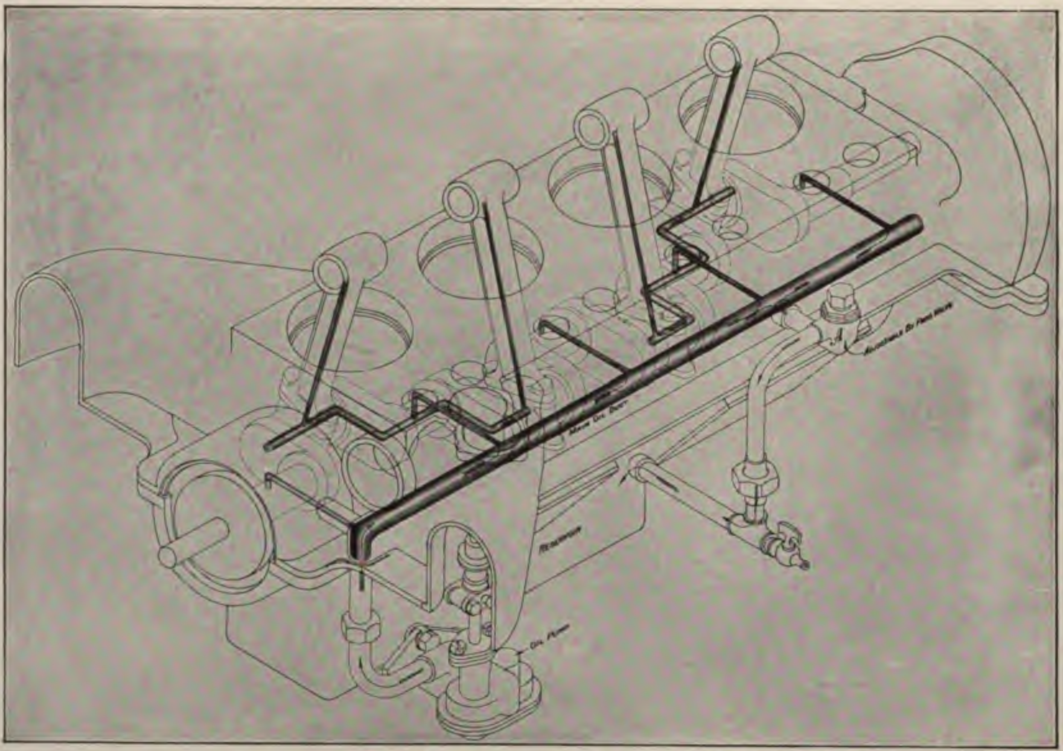
The lubricator is driven by a steel belt, and a manifold, placed on the dashboard, is supplied with sight feeds, or "telltales," so that the operator can assure himself that the lubricator is working properly.

The splash system of lubrication as employed in this typical case is very effective, and special provision is made so that the wrist pins receive a sufficiency of oil. This is accomplished as follows: A horizontal groove cut near the bottom of each cylinder is always kept full of oil which is splashed up from below, and when the piston reaches the bottom of the stroke, the oil which has collected in the groove enters the hollow ends of the wrist pin and works out to its bearing circumference by means of holes cut through the diameter. Every precaution is taken to insure thorough lubrication of the crank-pin bearings. Holes are drilled in the edges of the crank webs communicating with holes drilled through the crank-pins both transversely and longitudinally; thus, as the crank-shaft revolves, it collects oil which works through these passages to the crank-pin bearings, insuring thorough lubrication. The three main bearings of the crank-shaft are fed from oil pockets which collect oil splashed about by the crank-shaft; this same method of lubrication is also employed for the cam-shaft bearings, of which there are ten in number—five for the admission cam-shaft and five for the exhaust cam-shaft. The aluminum housing at the front of the motor containing the timing gears and the governor is supplied with a pipe leading from the mechanical lubricator to the case and thus engine oil may be fed in any desired quantity.

An engineer's oil-can with a long spout is carried under the bonnet where it is always ready for use. The base of the can rests on a bracket secured to the dashboard and a spring clip prevents the oil-can from rattling or working loose.

The Knox Lubricating System.

The Knox system of lubrication is the same as always used on all Knox 4-cylinder motors and is what is known as the French De Dion 1906 system, used on several of the highest class American cars and during the year 1908 adopted by several prominent foreign makers. This system is claimed to



The Knox Lubricating System.

be the most reliable and economical used on motor cars, one exceptionally nice feature being the absence of odor or smoke at all times.

The camshaft near the rear end drives an upwardly projecting shaft for the ignition timer, and a downwardly projecting shaft for the oil pump. The lower portion of the crank case forms an oil reservoir from which, through a strainer, lubricant is drawn by the gear-driven pump previously referred to, and conveyed through passages formed in the crank case proper to the various rotating bearings of the crank and camshafts. In each connecting rod is drilled an oil passage, the opening of which registers once in every revolution with a similar opening in the crank pin, so that the wrist pin is not only lubricated by the oil distributed centrifugally, but by direct pressure through the connecting rod. The cylinders are amply lubricated by a mist of oil at all times present, the surplus oil falling back into the reservoir and, after straining, being again used. A pressure gauge attached to the dash registers the amount of pressure, which is varied at will by means of an adjustable spring by-pass.

Winter Treatment for Engines.

Force of circumstances occasionally compels the car to be laid on one side for a few weeks, and when this happens there are one or two points in the treatment of the motor which are well repaid—in more ways than one. A car that is driven straight into its quarters and left there for two weeks, or perhaps a month, deserves some slight consideration. In the first place it is an excellent plan to inject into the cylinder or cylinders, as the case may be, a small quantity of kerosene. It is obvious that what is good for one cylinder is, generally speaking, good for any number, so that unless it is specifically stated that a certain thing is only good for a certain engine, the matter may always be interpreted broadly. The reason for the use of kerosene is to clear the cylinder walls of lubricating oil, which is liable to oxidize, and so cause the piston to stick. Kerosene cleans the cylinder and piston, keeps the piston rings free, and still leaves a protecting coat of oil on the working parts.

While the cylinders are being cleansed with kerosene, the waste oil drain cock in the crank chamber should be opened, and the thick old oil run out. If the oil looks particularly dirty, it will do no harm to close the cocks and put into the crank chamber not less than a pint of kerosene. Give the starting handle a few vigorous turns, and then leave the engine for about ten minutes, at the end of which time open the drain cocks again. After using kerosene it is necessary to leave the drain cocks open for at least twenty-four hours, in order to clear away all the kerosene possible.

Expelling Dirty Oil from Crank Chamber.

A point that cannot be too strongly emphasized is the necessity for proper engine lubrication. A great many automobilists seldom give a thought to the matter of letting out the old oil from the crank chamber. It is a dirty job, so they just snap up their lubricator buttons, and allow the engine to go on as usual. The chamber wants a good flushing out with kerosene occasionally, for it should be remembered that dirty oil is charged with metal particles in a very finely-divided state, and consequently forms a first-class grinding medium.

Oiling the Clutch.

In many cars it is necessary to take up the floor boards for the purpose of oiling the clutch boss where it slides against the pressure of the clutch spring on the squared portion of the clutchshaft. Frequently, too, there is no lubricator fitted to the clutch boss, but merely a hole drilled therein, into which but little oil can be introduced, and that little is flung out again by centrifugal force as soon as the clutch starts revolving. For this reason this part of the mechanism requires very frequent attention in many cars, and this it does not get for the reasons given. We draw attention thereto because, unless some trouble is taken in this respect, the pedal work is apt to become laborious. Good machine lubricating oil should be squirted into this hole, and the clutch pedal worked vigorously up and down. The collar, too, in which the clutch-striking fork works in such systems must also be kept thoroughly well lubricated to insure easy clutching, declutching, and the saving of friction. Some means of automatically lubricating these parts should be fitted to all cars; but until such is the case, those whose driving economy is as we have sketched it must take up the floor boards and see to the matter.

Again, if the car owner will examine his flywheel, he may find a hole about three-sixteenths of an inch in diameter drilled through from the outside of the rim. This is for the purpose of introducing a softening agent to the surface of the clutch leather, when used, and very useful it is. Such convenient refinements are rare in the older cars, but the necessary treatment can thereby be afforded the clutch leather with much greater comfort than squirting whatever is used for the purpose through the narrow space between the two coned surfaces. The hole in the flywheel rim is also most useful for the introduction of gasolene to the leather of a slipping clutch. When applying either the oil or gasolene, the clutch should be held out just clear, and the engine turned round from time to time to get the dressing well distributed all over the leather.

Washing Out the Gear-Box.

After running a new car about 300 miles or so, it is advisable to drain all the lubricant out of the gear-box, wash the latter out well with kerosene, and, having allowed the gearbox to remain open and drain, to replenish with fresh lubricant.

Squeaks.

Failure of lubrication in any part of a motor and car is usually announced by a squeak, which may or may not be a matter of serious consequence. The automobilist should always endeavor to locate the squeak at the earliest possible moment, and the first point to note is whether the squeak appears to keep rhythm with the engine or with any portion of the gear, or whether it be an intermittent squeak without any particular period of frequency. One point is worthy of remark—that a sparking plug will occasionally develop a leakage round the wire or at the joint, which will give a squeak very similar to a squeak due to want of lubrication. Should this be suspected, the sparking plugs may be changed or new copper washers fitted.

Steering Joint Lubrication.

The question of lubrication of steering pivots has been rather a neglected one. Of late makers have been drilling the pins and inserting lubricators, but formerly the most usual method was to cover the pivots with a leather casing, and fill up with grease. Now if it is at any time necessary to remove the leather, there is the utmost difficulty in returning it. The reason is not hard to seek, for when putting the leather on, a piece is just twisted round the rod and arm and bound with wire. It is not difficult to arrange this differently, so that not only can the leather be taken off and put on, but so that it will make a tighter job and retain the grease better. The joints should be studded and the leather cut so that the flat piece of leather is a development of the parts which it has to cover; that is to say, when cut, it will resemble a T somewhat, the tail wrapping about the distance rod and the crosspiece folded over and inclosing the steering arm. Two thongs should be left cut diagonally from the junction of the tail with crosspiece, these thongs wrapping over and completing the case at the joint.

Lubricating Chains.

The only satisfactory manner in which driving chains can be lubricated is first of all to cleanse them thoroughly with kerosene, making sure that each roller of the chain is revolving freely on its rivet. Then place the chain, rolled up, into a shallow tin and put over it several lumps of good tallow which has been refined previously. The refining may be done by putting the tallow into a bucket of hot water and keeping it well stirred. All foreign matter will be precipitated, and, upon cooling, a cake of pure grease will be left on the top of the water. The tin containing the chain and tallow should then be put on the top of a stove which is only moderately warm. The chain will become heated slightly—not sufficient to alter its temper by softening, but enough to permit of the tallow being melted and finding its way into the spaces between the rollers and the rivets, where, obviously, it is required most. Some owners use a mixture of graphite with tallow, but graphite sinks to the bottom of the melted tallow, and, therefore, does not always do the duty that is expected of it. In order to prevent the collection of dust and dirt on the chain as much as possible, when the chain is removed from the tallow it should be hung up and all superfluous grease allowed to drain from it into the tin placed beneath. There will remain, of course, a thin film of grease over the surface of the chain, but no more than is sufficient to protect it in wet weather, though even this film of grease will collect dust. Practically, the only efficient way of properly lubricating a chain is to have it incased in an oil-retaining gear-case.

Drip Feed Adjustment.

A little item of great importance which is often overlooked has relation to the adjustment of drip lubricators. The practice is too common of leaving these appliances just as received from the makers, with the result that the frequency of the dripping varies in accordance with the viscosity of the oil used. A lubricator may be set to supply accurately a sufficient and not excessive quantity of one particular kind of oil, but when upon a tour some different brand of oil may be purchased which will not drip through the orifices of the lubricators with anything like the freedom of the oil for which the lubricators have been adjusted, with the result that the engine receives an inadequate supply; or an oil of a much lighter body may be purchased which will drip through so rapidly as to smother the sparking plugs and valves.

On Lubricating Oils.

In a number of motors, although the compression is good, power is not developed in accordance with the size of the cylinders, and there appears to be a decided tendency to overheat in the engine. This is often due to using a lubricating oil that is not suitable for the type of engine, as it is found that an oil which gives good results with one type is worthless with another. An oil may appear thick, and yet under the heat and working conditions may thin out to such an extent as altogether to lose its lubricating quality. If this is experienced with water-cooled motors, a good brand of oil usually employed for air-cooled motors should be tried. The results will be found to give satisfaction in most cases.

Heavier Lubricating Oil for Summer.

Each summer complaints are heard as to overheating of engines. In a number of cases this is no doubt largely due to the employment of the wrong kind of lubricating oil for summer use. For water-cooled motors it is not a bad plan in such cases to use oil recommended for air-cooled motors, as this oil is much thinner in summer when in use, and consequently becomes about the right consistency for the proper amount of feed during the summer months. Of course, as the weather becomes colder the usual brand of lubricating oil should again be used.

Over-lubrication.

When a thick cloud of blue pungent smoke is ejected from the muffler it is a sign that there is too much oil in the engine. While it must be admitted that this is good for many engines, especially when new, it must not be forgotten that such an emission is highly objectionable to everybody but those in the car. A simple and effective method of correcting this trouble is to open the compression cocks, when such are fitted, one by one. This quickly clears the cylinder, and with a surprisingly small amount of attendant mess when there is a clear way for the ejected oil. With a single-cylinder engine it is, of course, necessary to give the piston the necessary movement by hand. It is a somewhat extraordinary thing, but many engines will run with quite an overdose of oil without trouble, while others have a very decided objection to a too liberal supply of lubricant. For instance, a Daimler car requires but a small amount of oil, while, on the other hand, a Mercedes simply gloats on a full charge. Many makers adopt the expedient of fitting an overflow pipe in the bottom of the crank chamber to prevent the engine getting more than is good for it.

Take Nothing for Granted.

Nothing should be taken for granted in the lubrication of an automobile. Everything should be done to make the work of lubrication as easy as possible by having every convenience at hand. The plugs and cocks designed for the drawing off of the spent oil from crank cases should be looked after carefully to see that they cannot work loose while running. If an undue amount of oil drips from any particular point of the vehicle, it may indicate either that the supply is excessive, that means for retaining it are not proper or that the oil is too thin. Thick oil, on the whole, gives little trouble from working out of bearings, especially when everything is worn. The cleaning down of a car is a duty which no one having the instincts of a mechanic will shirk, as the dust which an excess of oil on the outside surfaces of the wearing parts is constantly collecting may prove very injurious to the mechanism.

Preserving Oil Holes from Dirt.

Most users of cars are very neglectful in their oiling of short shafts such as brakeshafts, clutchshafts, and the like. They simply think that these parts can be left to take care of themselves, whereas they should be lubricated as regularly, although not so frequently, as the gear-box bearing or road-wheel bearings. As a number of brake spindles are carried on cast bosses which readily lend themselves to the fitting of clip rings over the oil holes, these clip rings, such as are usually fitted to the hub of a bicycle wheel, should be fitted over the oil holes, and thus no dirt or wet can be allowed to get in the shaft bearings. The brakes work much more sweetly and also clutchshafts have less friction, so that less effort is required to depress the clutch or apply the foot brake. Cases have been known of a rear brakeshaft which was absolutely rusted solid in its place, and could not be moved at all; thus the rear brakes were rendered quite useless through simple neglect of fitting clips and oiling the parts regularly.

Kerosene Pump Lubricator.

If your car is unprovided with means by which kerosene can be injected into the cylinder, and the latter is not fitted with a compression cock, have a kerosene pump lubricator fitted to the dashboard with a delivery pipe, or, in the case of multiple cylinders, forked delivery pipes to the lubricating pipes, as close to the entrance of the latter to the cylinder as possible. The cylinder oil pipes must be provided with cocks just above the junction of the kerosene pipes, so that by turning off these before you do your kerosene pumping on coming in from your run, the latter oil is not forced back, as it may be, into the cylinder oil tank. Above all, do not forget to turn these added lubricating oil cocks on directly after you have flushed with kerosene. Forgetfulness in this particular may mean seizing, with all its horrors.

Cleaning Grease Pipes.

It is not often that grease pipes require clearing out, for which we ought to be duly thankful, for if the pipe be of any length, or contain complicated turns, then there are great possibilities of trouble. The best way to start is to pass a piece of stiff wire through the grease in the pipe, if possible, and if this may be done, then lay the pipe in a tray and keep it covered with gasolene. This treatment will soften the grease, and clear some of it out, so that the pipe may be charged with successive doses of gasolene and cleaned like a bottle. If one is lucky enough to have access to a steam boiler, then the pipe may be cleared by attaching it to the blow-off cock on the water gauge. It needs caution, however, when following this method of procedure, or scalded hands or worse may follow. The safer plan is most certainly that first outlined, but the latter is much quicker and cleaner.

For cleaning out the small pipes, a very good method is to use a pump made out of a bicycle tire inflater. this being provided with a brass nozzle with a coned end, so that it can be put into the end of the pipe and the contents vigorously discharged through it, thus dissolving and clearing away any congealed oil or other obstructive matter.

Grease Injection.

Some cars require grease to be injected into most inaccessible places. We have in mind a machine which takes grease for its differential and for its two-to-one gear through holes of one inch in diameter, these holes being covered with screw plugs. Now, to push sufficient grease through these small orifices is a dirty and almost interminable task. The owner overcame the difficulty by pressing into service an old grease lubricator of the screw-down type. This lubricator was a gunmetal pot about four inches wide and as many deep. In the screw lid there is a piston with a screw handle, so that when the pot is filled with grease it can be forced out by turning the handle round. At the bottom of the pot there is a piece of copper tube eight or ten inches long, so there is nothing easier than to insert this tube into the holes and then to screw down the lubricator, thus emptying its contents into the gear-box.

It may be interesting to add that we have found the easiest way to handle grease, when one is filling the pot or putting a considerable quantity into the change speed gear-box, is to use a small garden trowel kept especially for the purpose, and entirely free from grit. This is a very clean and quick method of dealing with 8 or 10 lbs. of grease, and infinitely more satisfactory than the ordinary way of picking up small pieces on the end of a flat piece of wood, or digging one's hands into the mess and throwing it handful by handful into the box.

Care of Grease Lubricators.

Pressure should always be kept on screw-down feed lubricators serving grease on to bearings. Owners should get into the habit of giving the caps of the lubricators an eighth, quarter, or half-turn frequently. Overmuch is vastly better than too little lubrication in such bearings as are so served.

When taking over a new car, make certain that the grease lubricator has been filled and screwed down, and filled and screwed down again and again, until the grease is really serving on to the bearing, for in some cars the pipe leads from these lubricators are so long that several charges of the lubricator are necessary to fill the pipe before the grease really reaches the bearing. New bearings have seized or stuck before now for lack of this precaution.

It is often noticeable that the ordinary screw-down lubricator is very hard to manipulate. This is due to the feed-hole at the bottom of the lubricator being too small or to the lead pipe communicating with the bearings having too small a bore. There is no reason why screw-down lubricators should be made so difficult to operate; this matter really deserves more attention from the manufacturers and those who have to use them. The screw portion should be capable of being easily twisted round by means of the thumb and forefinger, and not have to be forced down with the hardest stress which can be put on with the hand or with a spanner.

Commutator Troubles.

Car owners whose high tension ignition systems include a rolling contact maker of the Lacoste type cannot be too careful about the lubrication of the commutator. When cars so fitted are first received from the makers, the interior of the commutator case will or should be found packed with a somewhat thin grease, with which the action of contact-making as the roller on the little arm passes over the brass or steel terminals appears to be as perfect as possible. After four or five hundred miles, the engine may be found to fire imperfectly on one or more cylinders, particularly when accelerated, and then such failures will frequently find their cure by the careful washing out of the commutator with gasolene, and, when the latter has dried off, the application of fresh grease. Care, however, should be taken as to the grease applied, for there are several very stiff kinds sold which, though good enough for bearings, are by no means suitable for commutator lubrication.

An Oil Force Pump.

It is a great convenience to have a force pump for oil on the car—some 7 or 8 inches long, and really well constructed. With this the very thickest of oil can be picked up and injected into almost any part of the car. It is most useful for lubricating many places, and comes in handily in a number of ways. For instance, supposing it is found when on the road that the differential should be lubricated. The arrangement for this in some cars is rather crude, and the only provision for lubrication is to undo a screw plug at the top or the side of the differential casing—we are speaking of gear-driven cars —and it is a long job to empty an oil can into the case, but three or four syringefuls of oil can be injected in a very short time indeed. The pump can also be used for kerosene for cleaning purposes, though, of course, after being so used it should be thoroughly cleaned with stale gasolene before being used again for lubricating oil. The pump can also be used for introducing grease into awkward places. The quickest way to do this is to put the grease in a breakfast cup or small pot, and place the vessel in a pan of boiling water. The grease will then be taken by the pump as though it were thick oil. To prevent the fingers being burned with the hot pump, a thick rag should be used as a protection, especially if the pump has, as it should have, a couple of hooked finger plates at the end of the barrel, as well as a finger ring on the plunger.

Lubricators for Spring Shackles.

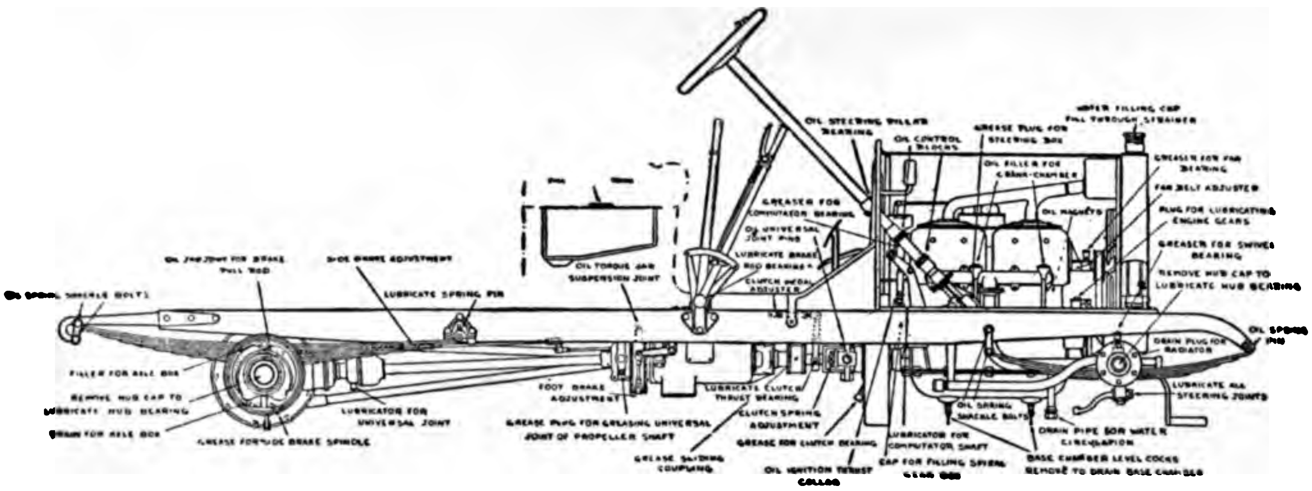
Many cars, especially high priced ones, are fitted with lubricators to each of the bearings on the spring shackles. Lower priced cars have merely oil holes, and the user is expected to fill these from time to time. In cheaper cars these oil holes are omitted, but where possible they should be made, as wear sets up in the joints of these shackles and has a tendency to cause rattling after the car has been on the road for a few months. Where the oil holes are provided, and it is desired to close them in some way, this can be done quite easily by the user himself, by means of the covers such as are used on bicycles. The types we refer to more particularly are the spring bands which are used on bicycle pedals. These can be obtained of different sizes, and can be sprung round the shackle bearings effectually to prevent dust getting in, and yet allow easy access to the holes when necessary.

Good Mufflers and Lubrication.

Where in some cars the muffler has been carefully studied to avoid back pressure, this may have been done so effectually that a very feeble pressure passes to the lubricator, and sometimes on a cold day no feed therefrom can be obtained. When this is so, there are two courses open: The first is to force some oil through the pipes, and that can be done by getting someone to put the sole of his shoe over the exhaust outlet, when the throttle can be opened; the engine will not race, as it will be slowed by choking the exhaust outlet. This will cause the oil to pour through the lubricator sight drip jets in fine style. The second procedure is slightly to warm the oil. This can be done by arranging a leak somewhere, so that the exhaust coming into the lubricator can pass right through for a time, and so gradually get some warm air through. If, however, the lubricator used to feed well, but becomes worse as time goes on, there is another thing to be looked for, and that is, that the oil, for some unexplained reason, has found its way into the oil pipe that connects the lubricator to the large exhaust pipe, and has become crusted up. This has been found the case with many cars under repair, and it is a thing one might look for indefinitely without finding it out.

The Smell from Cars.

There is no need for us to dwell upon the evils of over-lubrication so far as smoke and smell are concerned, but there are some cars which, whether they be over-lubricated or not, always smell more or less, and it will be found that this smell is different from the ordinary odor of burned lubricating oil. In most cases it is due to oil or grease leaking from the gear-box and thrown by the shaft on to the hot exhaust pipe. At this point the pipe may not be hot enough to


OIL SPRING SHACKLE BOLTS
OIL JAW JOINT FOR BRAKE PULL ROD
SIDE BRAKE ADJUSTMENT
LUBRICATE SPRING PIN
FILLER FOR AXLE BOX
REMOVE HUB CAP TO LUBRICATE HUB BEARING
DRAIN FOR AXLE BOX
GREASE FOR SIDE BRAKE SPINDLE
LUBRICATOR FOR UNIVERSAL JOINT
OIL TORQUE BAR SUSPENSION JOINT
FOOT BRAKE ADJUSTMENT
GREASE PLUG FOR GREASING UNIVERSAL JOINT OF PROPELLER SHAFT
GREASE SLIDING COUPLING
LUBRICATE CLUTCH THRUST BEARING
CLUTCH SPRING ADJUSTMENT
GREASE FOR CLUTCH BEARING
OIL IGNITION THRUST COLLAR
GREASER FOR COMMUTATOR BEARING
OIL UNIVERSAL JOINT PINS
LUBRICATE BRAKE ROD BEARINGS
CLUTCH PEDAL ADJUSTER
OIL STEERING PILLAR BEARING
OIL CONTROL BLOCKS
GREASE PLUG FOR STEERING BOX
OIL FILLER FOR CRANK-CHAMBER
OIL MAGNETO
WATER FILLING CAP FILL THROUGH STRAINER
GREASER FOR FAN BEARING
FAN BELT ADJUSTER
PLUG FOR LUBRICATING ENGINE GEARS
GREASER FOR SWIVEL BEARING
REMOVE HUB CAP TO LUBRICATE HUB BEARING
OIL SPRING PIN
DRAIN PLUG FOR RADIATOR
LUBRICATE ALL STEERING JOINTS
OIL SPRING SHACKLE BOLTS
DRAIN PIPE FOR WATER CIRCULATION
BASE CHAMBER LEVEL COCKS REMOVE TO DRAIN BASE CHAMBER
LUBRICATOR FOR COMMUTATOR SHAFT
CAP FOR FILLING SPIRAL GEAR BOX

LUBRICATION OF A TYPICAL MODERN CAR.

The motor is lubricated from a reservoir on the dash board fitted with sight feeds leading to the main bearings. The oil drips through these feeds, and must be adjusted to feed the right number of drops to each part. The crank should have 8 drops per minute, the connecting rods 10 drops per minute, the cylinders 10 drops per minute, the crank shaft 8 drops per minute. The oil in the base chamber should be maintained at the level of the overflow; it should be replenished and washed out and renewed occasionally. *Daily.*—When preparing a car for a run, one or two drops of oil are required at the following points—valve operating plungers and guides, control levers on steering column, accelerator shaft and joints of throttle levers, clutch on disengaging collar, pin joints of brake mechanism, pin joint of link of torque bar. Each grease lubricator one turn. *Weekly.*—The grease lubricators require filling every week in addition to giving one turn every day before using the car. They are applied to the various parts as follows:—Clutch bearing, universal joint between clutch and gear box, the two universal joints of the propeller shaft, the bearing of the fan spindle, the gear lever and quadrant, the swivels, and the levers and rods of the steering gear, the contact maker, the shaft of the internal expanding brakes, the wheels. The axle caps should be screwed off and filled with grease every two weeks. The box containing the worm and segment should be filled with thick oil or grease every three months through the cap provided. The gear box should be replenished with thick oil through the inspection cover on the top, as required, to keep it full up to one inch below the centre of the gear shafts. The bevel gear which drives on to the back axle requires to be filled in the same way. The covers should be removed from all steering connections and re-packed with grease occasionally.

really burn the oil up immediately, but it gradually fries it, and makes a most unpleasant odor in so doing.

The remedy is a simple and obvious one. As a rule, the leakage, if round the primary shaft of the gear-box bearing, cannot be stopped, and the thing to do is to protect the exhaust pipe from the splashes. This can always be done by fitting a thin sheet iron shield an inch or two from the exhaust pipe and between it and the line of the oil splashes.

When driving slowly, too, it has been found that in many cases cars which have the muffler in front of the back axle are much more likely to emit unpleasant odors, of which the occupants of the car are unpleasantly conscious, than if the muffler is fitted further back. The muffler at the back with the final exhaust directed at a slight downward angle is less likely to cause inconvenience. Of course, it will be understood that the angle of the exhaust as it issues to the air will be only slightly downward. It will never beat upon the road, and if a line were taken from it to the road it would not touch the ground till it was at least ten or twelve feet behind the car, so that it has no disturbing effect upon the dust; in fact, if anything, it should tend to reduce dust raising.

Lubrication, Forced-Feed—See under Lubricators.

Lubrication, Gravity-Feed—See under Lubricators.

Lubrication, Lack of—See under Loss of Power.

Lubrication, Ring—See under Lubricators.

Lubrication, Sight-Feed—See under Lubricators.

Lubrication, Splash—See under Lubricators.

Lubricators—These may be classed under two heads—gravity feed and forced feed.

Gravity Feed.

In gravity-feed lubricators the lubricant is placed in a chamber higher than the point at which it is to be applied, and by its own weight travels down to the oil squeezed from between the surfaces to be lubricated. Even where a simple oil cup is placed in a bearing it acts by gravity, the oil dropping down to replace that used up.

It is generally considered necessary to provide in this system of lubrication for some form of sight feed, so that ocular demonstrations may be obtained as to whether the oil is flowing or not.

Sight Feed or Drip Lubricators—Generally placed on the dashboard of the car, and immediately under the eye of the driver. The oil drops from the oil chamber through a needle valve, which can be regulated to allow it to pass the oil in the form of drops through a glass tube where the speed of the dropping can be easily seen, and the needle valve can be easily adjusted to cause the requisite number to fall in a given time. A number of these drips or sight feeds can be arranged from one oil reservoir, each one communicating by a pipe to the particular part of the car to be lubricated.

Forced Feed Lubricators.

In forced feed lubricators the oil is forced by a rotating or reciprocating pump, via small tubes, to each journal or bearing to be lubricated. It flows in a constant stream as long as the engine continues to run and to drive the pump. The oil flows over and around or through the bearing or sliding surfaces, and is collected in a drain chamber somewhere below the bearings, generally in a recess formed in the base of the crank case or gear-box for this purpose. It is from this chamber that the pump draws its supply, so that there is a constant circulation of the oil from the oil pump to each bearing and back to the oil pump again.

The feed of the oil from the tank may be either by gravity, as we have seen, or forced. In the latter case the tank may be placed in any convenient position on the car, and the oil is forced from it by air pressure in the tank itself. This air pressure may be obtained by means of a small hand pump, and a pressure gauge on the dashboard indicates to the driver if the requisite pressure is in the tank to keep the oil properly fed to the different bearings.

In another system the pressure of the exhaust gas is used to force the oil through the oil pipes to the various bearings. Part of the exhaust gases are passed through a non-return valve and filter into the oil reservoir, maintaining such pressure as may be required, a pressure relief valve being sometimes fitted to prevent the pressure in the tank rising above a predetermined amount. This system has the advantage of slightly raising the temperature of the oil, and this allows an oil of greater viscosity to be used.

In all cases the oil passes through sight feed lubricators on the dashboard, so that the driver may be assured that this important operation is going on properly. See Internal Combustion Engine.

Forced feed lubrication is also used in some cases on bearings which are fed with heavy grease. In a lubricator of this type the thick grease is contained in a cup which has in its top a plunger pressed down on the grease by a helical spring. As the grease is used up in the bearing and flows away, the spring plunger forces the thick grease down to take its place.

Pump Lubricators—The pump lubricator is almost always of the screw-down grease cup type.

Ring Lubricators.

These are now often used, especially in the bearings of engine crank shafts and the shafts of change speed gears. In this type the center part of the bearing is cut away, forming an annular chamber around the journal or shaft. In this chamber and around the shaft hangs a loose ring of larger dimensions than the shaft. The bottom part of this ring dips in an oil bath in the bottom of the annular chamber, and as the shaft revolves it revolves the ring hanging upon it, which carries around with it the oil from the oil bath, and deposits it over the shaft, from which it runs to the bearing parts at each side of the annular chamber.

Splash Lubrication.

This is used for lubricating the crank pins, gudgeon pins, and pistons of engines either independently or in connection with drip lubricators or force pumps. In this system the crank case is filled with lubricant to such a height as will allow of the cranks dipping into it at the bottom of each downward stroke. The oil is then splashed upward, and effectively lubricates the whole of the inside wearing parts of the engine. The oil, which is very thick before it is put into the crank case, but becomes thinner afterward on account of the rise in temperature which it there encounters, is forced into the crank case by means of a hand force-pump, generally situated on the dashboard, and provided with a cock, which communicates with the crank chamber, one or two strokes of the piston of this pump supplying oil for a determined number of miles running. See Lubrication, under Repairs and Adjustments.

Graphite Lubrication.

A mixture of graphite or plumbago and grease is often used on the chains, chain wheels, and chain sprockets of chain-driven cars, especially in cases where such chains are not protected by efficient chain cases.

Lubricators for Spring Shackles—See under Lubrication.

Lubricators, Care of—See under Laying up a Car; Lubrication.

Lubricators, Sight-feed—See Lubricators.

Luck and the Tire Bill—See under Driving.

Lug—A block for keeping a slide in place, etc.; any projecting or hanging part.

Lug-bolt—A bolt with a head in the form of a strap or flat iron bar.

Lunette—A small glazed window in the rear of a closed car or a mica-covered window in the rear of a removable top, to enable the occupants to see behind the car.

M

M., m.—An abbreviation of meter, mile, or minute.

M., m.—In mechanics, an abbreviation of Mass.

Macadam—The name given to roads built on the rules laid down by the Scottish engineer, John Loudon Macadam (1756-1836). The generic term for roads made of broken stone, as distinguished from those paved with stone blocks or cobbles, or covered with asphalt, wood, etc.

Macadamization—The process of laying roadways according to the process or system of Macadam.

Machine—A contrivance, device or structure by means of which a force or forces may be advantageously applied, as a dynamo, an automobile, etc. An engine or any instrument for the conversion of motion. The term is specifically applied to a motor car as a whole. This revives an old English use of the word as applied to a vehicle or conveyance.

Machine, Elementary—A single mechanical contrivance, such as a lever on an inclined plane.

Machine, Flying—An apparatus for navigating the air; an aeroplane, dirigible balloon, etc.

Machinery—The mechanism of a machine; the working parts; any combination of appliances resulting in successful operation.

Machinery, Cleanliness of—See under Cleaning.

Machine Screw—A screw, usually with a fine thread, suitable for screwing into iron: distinguished from a wood-screw.

Machine Tool—A tool for cutting, shaping, etc., used by a machinist as an adjunct to a lathe or some other machine, as a drill, a punch, a reamer, etc.

Machining—The operation of making with a machine or of applying machinery to. Machine-work is work done by the aid of machinery as distinguished from work done by hand.

Magnet—A piece of steel or iron which has become magnetized or made capable of attracting or repelling another piece of steel or iron. Magnets are of two kinds—permanent and electro. The former are always of hard steel; the latter of soft iron. Permanent magnets in motor practice are only used in magneto machines. Electromagnets are used in the armatures of magnetos and in the cores of induction coils. (See Ignition; Coil.)

A small permanent magnet is useful to carry for the purpose of extracting minute iron or steel particles which may get into the eye in working at a car. It should always be supplied with a "keeper," a bar of iron across its poles, so as to prevent it losing its magnetism. It should not be carried among tools or spare parts.

Magnet, Horseshoe—A magnet shaped like a horseshoe or arch of horseshoes, having its poles side by side.

Magnetic Clutch—See under Clutch.

Magnetic Curves—Curves representing magnetic lines of force as seen when iron filings are placed upon a sheet of paper in proximity to a magnet.

Magnetic Density—The intensity or strength of magnetism indicated by the number of magnetic lines of force in a given cross-sectional area at right angles to the lines of force.

Magnetic Field—The air space surounding the poles of a magnet; or the space between the poles of an electromagnet—as in a dynamo; or the area influenced by magnetic lines of force, in any circuit or coil of wires carrying an electric current.

It may be termed, shortly, the sphere of action of the magnetic lines of force.

See Principle of the Motor, under Electric Motor.

Magnetic Force—A force which tends to make a magnet assume a position in the direction along which the force acts; also applied to the forces of attraction and repulsion characteristic of a magnet.

Magnetic Induction—Magnetization induced in a magnetizable substance when brought into a magnetic field.

Magnetic Moment—The force exerted by one pole of a magnet multiplied by the distance between the poles.

Magnetic Plug—A spark plug containing a magnet, used in a make-and-break system of ignition.

Magnetic Saturation—A bar is said to be magnetized to saturation when a maximum of permanent magnetic force has been imparted to it, this amount depending upon the material of which the bar is composed.

Magnetic Valve—A valve operated by means of magnetic force.

Magnetism—The quality or condition of being magnetic; that force characteristic of a magnet which is manifested in nature.

Magnetite—Ferrous oxide or magnetic iron ore, which occurs in nature in massive or crystal forms. When possessing polarity it is called lodestone.

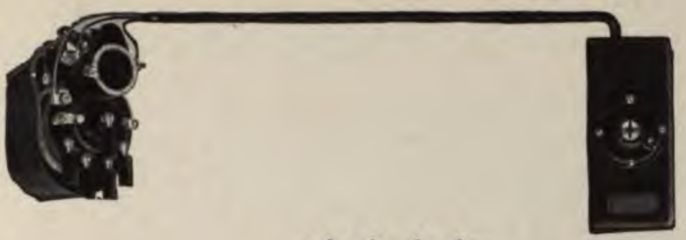
Magnetization—The act of magnetizing or the condition of being magnetized.

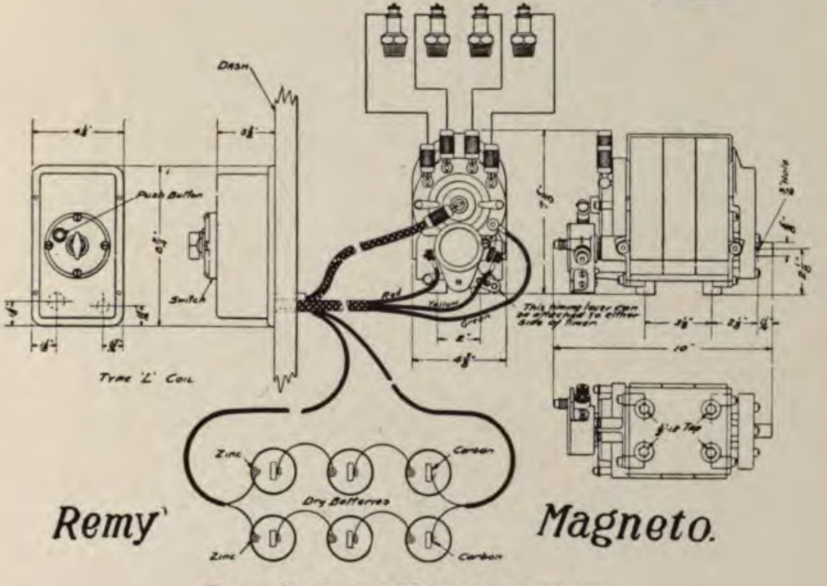
Magnetization, Intensity Of—Same as Magnetic Density.

Magneto—A mechanical appliance used to transform magnetic energy into electric energy. The term is an abbreviation of the full title Magneto-Electric Machine. See Magneto Ignition under Ignition where the principles of the magneto and of the systems commonly employed in motor-car ignition are gone into very fully.

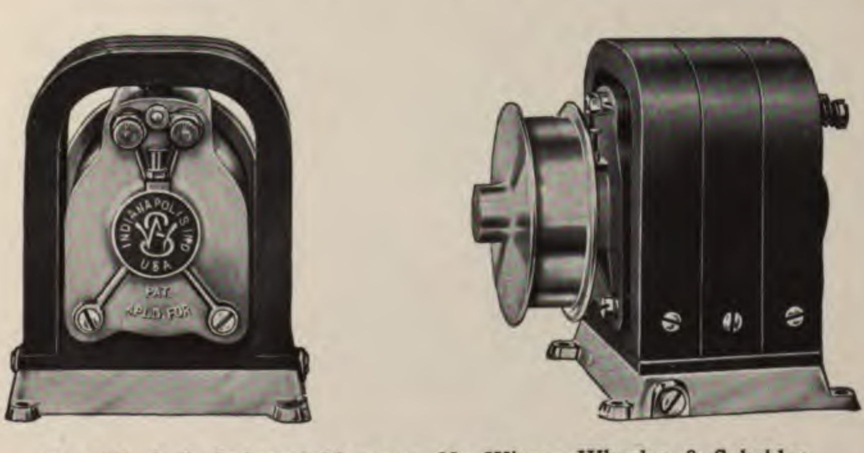
The Remy High Tension Magneto System.

The Remy high tension magneto has a stationary winding which simplifies the construction and does away with moving contacts in the primary circuit. A single coil of No. 18 magnet wire is embedded in the pole pieces of the magneto. The rotative part or inductor is a simple forging mounted upon a solid steel shaft. At each half turn or revolution, the direction of flow of the lines of magnetic force through the coil is





Four-Cylinder Wiring Diagram



The W. & S. Inductor Magneto—No Wires.—Wheeler & Schebler, Indianapolis, Ind.

[illegible]

alternately reversed, inducing in the coil two electrical current waves or impulses for each revolution. The magneto winding is directly connected through the magneto circuit breaker with the primary of the spark coil used with the magneto. The circuit is mechanically broken during the current wave which is of considerable duration (over 45 degrees of the inductor's revolution). The nature of the wave, due to careful design, is an almost abrupt rise and fall, with a flat top making possible a large timing range for the advance and retard of spark at practically the same heat of spark. The timing of the spark is accomplished by shifting the circuit breaker around the armature shaft, to which is attached the circuit breaker cam.

The distributer of the magneto and its two-to-one driving gear for the four-cylinder motor is for the purpose of distributing the current after it has been sent to the coil and transformed to the high voltage which it is necessary to use at the spark plugs. One high tension cable leads from the coil to the distributer. For each revolution of the magneto inductor, this cable carries two high voltage current impulses to the distributer, and as the fan shaped distributer segment is making one revolution to two of the magneto inductor, it can in turn deliver a spark to each of the four cables leading from the distributer to the spark plugs each time the magneto inductor makes two complete revolutions. The magneto inductor must therefore, with the four-cylinder, four-cycle engine, always be driven at twice the speed of the engine camshaft or the same speed as the crankshaft.

With the six-cylinder, four-cycle engine, the magneto distributer is back geared with a ratio of one to three and the magneto must be driven at three times the speed of the camshaft or one and one-half times the speed of the crankshaft.

With the two-cylinder, four-cycle, opposed engine, the Remy magneto does not have a distributer and a single cam is furnished on the magneto, causing but one electrical impulse for each revolution of the magneto inductor. The magneto must then be driven at the same speed as the crankshaft of engine.

The special spark coil furnished with the Remy magneto is fitted with a two-point switch used to switch from battery to the magneto or vice versa, or disconnect from either to stop the motor. The switch is also provided with a push button for the purpose of starting the four-cylinder or six-cylinder motor from the spark by pushing the button when the switch lever is turned to the battery side. This system, it is claimed, makes starting without cranking most reliable, for the reason that the coil is particularly suited to the magneto, which is not injured by large current consumption, as would be the case were batteries regularly used. When the battery is in use with the coil, it furnishes then an exceptionally hot spark. When the battery is used, the battery current is simply turned through the coil and distributer of the magneto instead of the magneto current. It is intended that batteries be used for starting and relay, although the magneto is regularly used for starting. Also see Magneto Ignition below.

Magneto Armature, Lines of Force in—See Ignition.

Magneto, Bosch—See under Ignition.

Magneto, Eisemann's—See Eisemann High-Tension Magneto.

Magneto Fatigue—See under Ignition.

Magneto Ignition—Ignition by magneto as applied to motor cars is divided into two broad classes, namely, the Low Tension and the High Tension Systems. These are fully described under Ignition.

Insulation of Magnetos.

In any type of magneto where the high-tension terminals are all secured to one ebonite body and the plugs attached thereto are pressed into corresponding holes communicating with the high-tension distributer, care should be taken, in washing the car, that no water is allowed to get on to this ebonite, as so surely as it does trouble will be experienced with short-circuiting. This short-circuiting is most annoying, because it is difficult to locate the fault. The slightest film of moisture is sufficient to cause the "shorting."

Short Circuit of High-tension Distributer.

Some makers of magnetos in the past have not appeared thoroughly to realize the fact that there must be very considerable wear on the working parts of these machines owing to the continued and fairly high speed at which they are run when used with gasolene motors. Trouble has sometimes been experienced in the high-tension distributers by fitting a wiper, say of hardened steel, while the contact pieces over which it rubs to cause the distribution of the high-tension current are of a softer material. These pieces are worn down, and produce fine dust over the whole surface of the high-tension distributer. This very fine metallic dust acts as an excellent short-circuiter to high-tension currents, and its presence can be readily detected by occasional misses of the explosions. This gradually becomes worse, until finally it is found practically impossible to start the engine when once it is stopped. A temporary remedy which may last from three weeks to a month is to take off the distributer cap and wipe the ebonite contacts quite clean with a very slightly oiled rag, and then replace the contact maker, when it will be found that trouble for the time ceases. This taking down of the contact piece must be done at fairly frequent intervals, and is quite unavoidable especially with the earlier forms of magneto.

Always Maintain the High-tension Circuit.

With the Bosch magneto do not make use of the safety spark gap except for an emergency. For instance, do not allow one secondary wire to remain detached from the plug when one cylinder is out of work. This puts a strain on the winding insulation, and may ultimately lead to a breakdown. Some magnetos, such as the Castle, may be connected up in exactly the same way as a battery, no special arrangement of the switch being necessary. This is the case when the contact breaker and primary coil of induction coil are in series, and not in parallel.

Wiring a Simms or Bosch Magneto to a Battery.

To employ a Simms, Bosch or similar type of magneto and also a battery and coil system with one set of sparking plugs necessitates a switch on the high-tension circuit and a considerable increase in wiring. It is best to use two independent sets of plugs, especially as the most probable cause of failure of the magneto system lies in the plugs themselves.

Setting of Low-tension Contact Points on Magnetos.

Much unnecessary trouble is experienced by users of high-tension magneto systems which have a mechanical make-and-break in the primary circuit, by failing to set the points of contact correctly. The usual error into which the uninitiated fall is that of adjusting the platinum-pointed screw too far away from the platinum point contact on the roller blade. It will be found that if the adjustment is made so close that contact is only just broken as the cam presses on the roller in its travel, the best results are obtained. About one-fiftieth of an inch is an excellent distance for all-round work. If the points are set much further apart than this, a very destructive spark takes place between the points at the moment of breaking the primary circuit. This rapidly burns away the platinum contacts, and necessitates frequent adjustment.

Setting of Sparking Plug Points.

When a magneto is used for the production of the ignition spark, care should be taken to see that the spark gaps of the sparking plugs are about half those employed with battery-provided current.

Low-tension Insulated Switches for Magnetos.

All low-tension switches of magneto machines should be insulated where they have to be handled. The insulation may take the form of an ebonite handle or a rubber tube pressed over the metallic handle. When the engine is running and it is desired to switch off, and the handle is uninsulated, if one hand is on the metal switch and the other on any metallic part of the car which is not insulated from the magneto, a terrific shock may be experienced. In one case a serious accident very nearly occurred by this happening to a driver while steering a car. The car in question was fitted with the magneto and battery system of ignition, with a two-way switch. While running, the driver desired to switch off from the magneto on to the batteries and, owing to the switch not being insulated, the operation of switching over caused a shock to be transmitted from the magneto through the body of the driver to the steering wheel, causing him to lose control of the machine and run up the side of a bank in the road.

Replacing Magnetos Correctly.

Some magnetos are driven off one of the distribution wheel shafts by means of a coupling which consists of two tongues cut on a disk, the tongues being at right angles. One of these tongues meshes with a groove in a boss on the distribution wheel shaft, while the other meshes with a groove on the magneto shaft. Before taking down magnetos, it is always as well to mark the jaws and the tongues carefully, so that they may be inserted in the same place when putting back in position. During the time that the magneto is down, the engine crankshaft should not be rotated, because if it is it might possibly happen that the driving wheel of the magneto will receive a revolution, so that the mark again comes to the top, and, apparently, is correct for the engaging of the joint driving the magneto. Such, however, may not be the case, and the firing may take place in a totally opposite position to that which it should. Thus in trying to start up the magneto, it will be found that back firing is occasioned in the carbureter. It is always as well, after parts have been uncoupled in this manner, to check the timing before trying to start up the engine.

Setting Magneto Tappets.

A loss of power in a low-tension system magneto fired engine may often be traced to the tappet giving the "tweaker," as it is sometimes called, too much of a "tweak." The tappet lifter, which causes the electric circuit to be broken inside the cylinder, has a definite lift, but as the tweaker is not directly connected to it, the spark may be adjusted in a manner analogous to the setting of the sparking plug points. This is done by screwing the threaded end of the tappet rod into or out of, as the case may be, the internally-screwed lifter, which is directly acted upon by the cam. The adjustment should be such that the tweaker makes a rapid jump from the insulated point, but the arc formed should not be too long, otherwise an attenuated spark is produced which has poor ignition qualities. On the other hand, if a short, quick break is given, a fine, fat, hot spark results, and the engine pulls with double the power.

Now, to adjust the tappet to produce the latter result, the engine should be turned round with the starting handle until the tappet lifter is at its highest point. Then screw down the tappet rod until there is a distance of about four millimeters between the underside of the tappet head and the tweaker. Next turn the engine until the tappet falls and hits the tweaker; this should be just before the tappet reaches its lowest point, at which it should be possible to pull the tweaker down a good way with the fingers. If a cylinder is found to be firing badly and not pulling as well as its companions, if of the multi-cylinder type, slack off the pinching screw at the head of the tappet lifter and screw up the tappet one turn; the correct movement is counter clockwise. If no better results follow, continue screwing up until nothing happens, and then start screwing down by one complete turn, for three turns, and then by half turns until the correct spark is obtained. This, of course, entails a lot of starting up of the engine; but, once found, no further adjustment should be necessary for a long period.

Incidentally, it may be mentioned that a long break at the "tweaker," in addition to causing bad firing, knocks a semicircular dent in the tweaker arm, and, again, this constant knocking wears the bearing in the ignition plate oval, and produces bad blowing and consequent loss of power.

Type D 2.

Type D 3 R.

Type Dr.

Type D 6.

Type D02.

The Bosch High Tension Magnetos.

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Care of Magnetos.

The best way to keep magnetos in order is to refrain from doing anything more than is absolutely necessary to them, such, for instance, as keeping the contacts clean and free from grease, and keeping the bearings sufficiently lubricated without flooding them. If a magneto is dismembered, the permanent magnets should not be left without keepers, that is, a piece of iron or steel bar across the ends of the U magnets. If not, it will result in the loss of a certain amount of magnetism, and a consequent diminution in the power of the machine as a producer of electric current. It is only under extraordinary conditions that the removal of the magnets is necessary, and therefore practically they should never be touched.

The Locomobile Magneto System.

The low tension magneto which furnishes electricity for the make-and-break system of ignition used in the Locomobile is typical of such systems and is described as follows:

"The magneto is placed on the admission side of the motor and secured to the front projecting arm of the motor base; dowel pins prevent the magneto from moving horizontally, and a steel strap passing over the magnets holds it down firmly in place. The strap is secured in a manner which renders it very convenient to remove the magneto should this ever be desired.

"The armature shaft is driven by a gear meshing with the admission cam-shaft gear and revolves at the same speed as the motor. A jaw coupling of simple construction is placed in the armature shaft so that in case it is desired to remove the magneto it can be done conveniently, and when it is desired to replace the magneto it can only be put back in the right way.

"Three pairs of powerful horseshoe magnets are used. The pole pieces are of cast-iron and are permanently secured to a heavy brass base by steel dowel pins and steel screws; the pole-piece bore is machined with great exactness and care and a specially constructed arbor is employed in assembling the pole pieces to the base, so that the air gap between the armature and the pole pieces will be not only as small as possible, but absolutely uniform. This is highly important, as the smaller the air gap, the greater the efficiency of the magneto.

"The armature shuttle, or 'H' piece, is wound with one length of the best double silk covered copper magnet wire, there being no joint or splice.

"The armature winding is insulated with rag-board, especially suited for the purpose on account of its high puncture-proof qualities and great flexibility. The armature winding and the rag-board insulation are thoroughly coated with a special elastic paint which forms a perfect insulation and which is also waterproof and oilproof. Three separate bands of brass spring wire firmly secure the winding, and mica insulation and rag-board are used between the banding wires and the armature windings. The armature when completed is not only thoroughly insulated, but is protected against injury from careless handling if removed from the magneto at any time. The brass armature shaft flanges are securely fastened to the shuttle by steel screws, locked in place by screw slots, and equal care is taken to secure the armature shaft to each flange, so that there can be no loosening at these points. It will be interesting in this connection to note that the driving end, or front end of the armature shaft is forced on to the front flange with a close drive fit, and then is further secured by drilling holes on opposite sides of the joint and driving in short steel pins which are thoroughly riveted over; inasmuch as these pins are partly in the armature shaft and partly in the header, it is impossible for the former to turn or work loose.

"The final turn of the armature winding consists of an insulated flexible cable, the end of which is secured to a brass contact bar by means of a brass screw permanently and securely fastened in place. The current passes through this contact bar to a steel stud to which it is permanently secured and the steel stud passes through the hollow armature shaft and is completely insulated by a one-piece hard rubber bushing. The armature shaft has a bearing at each end consisting of ground steel shafts running on bronze bushings, the bearings being lubricated from underneath by oil wicks standing in oil wells, and a hole in the side of the bearing cap regulates the height of oil in the well; if the oil wells are supplied with too much oil the surplus runs out, an arrangement preventing any accumulation of oil on the armature. A further precaution is the use of rings at both ends of the armature; these throw off any oil which might have a tendency to work in on the winding.

"Electric contact is made at the rear end of the magneto by a steel plunger pressed against the rear end of the armature by a spiral spring strong enough to insure contact but not too strong to cause any wear: the entire rear end of the magneto is enclosed by a removable bronze cap, so that it is impossible for water or dirt to prevent the proper movement of the plunger. A positive ground is secured by means of a carbon brush pressed against the armature by a spring, all parts being enclosed.

"The magneto delivers about one hundred (100) volts at one thousand (1000) revolutions per minute. Every magneto when completed is given a thorough test, both for voltage and for the quality of the spark. The magneto requires no attention beyond an occasional oiling—say, about once a month."

Magneto or Coil Wet—See under Missing Explosions.

Magneto Pin Lost—See under Motor Stopping.

Magneto, Simms-Bosch—See under Ignition and Magneto.

Magnetos, Various Types of—See Ignition; also Magneto.

Main Bearing—See Bearings.

Maintenance—See Care and Maintenance.

Make-and-break—This term is correctly used to describe the trembler blade type of contact maker, such as was fitted to the older types of De Dion-Bouton engines. See Contact Maker.

Make-and-Break Contact Breaker—See under Ignition.

Make-and-Break Ignition—A system of ignition in which a make-and-break device is used. See Contact Maker and Contact Breaker, also Ignition. 74

Make-and-Break, Magnetic—A magnetic sparking plug.

Make-and-Break System—See Make-and-Break Ignition.

Makeshift Cam, A—See Makeshifts on Tour.

Makeshifts on Tour—During the course of his experience every automobilist who has passed his novitiate has had occasional troubles which required a certain amount of ingenuity to overcome in the absence of spare parts or a well-stocked garage. Many have been so fortunate as to be able to meet every difficulty as it has arisen, without leaving the car where the trouble occurred, and some of the makeshifts employed by such ingenious owners are described below. Also see Miscellaneous Roadside Repairs.

Broken Exhaust Valves.

A well-known Eastern automobilist writes: "Some time ago I had a car, the engine of which (a four-cylinder) gave a deal of trouble on account of the exhaust valves breaking. The exhaust valve spring was of that type which, instead of being fitted with a cap and cotter, was bent hook shape at the bottom end, the hook being slipped through a slot in the stem of the valve. The point of breakage was always at the slot in the valve stem (see Fig. 1). On two occasions I had a spare valve with me, but on the one to which I refer the spare parts had by some mischance been taken out of the car and not replaced. Well, the valve snapped, with its usual absence of warning, about three miles from a small town, while we were on tour in the North, and then—and not until then—I found that the spares had been left at home. I therefore ran into the town mentioned on three cylinders, and, while having lunch, attempted to think of some way out of the difficulty without waiting for the spares to be sent on, for I guessed that it would be impossible to obtain a new valve in the town. At last I hit upon, and carried out with the help of a local bicycle repairer, the following repair: We first of all smoothed with a file the end of the valve stem B where it had broken, and then cut a piece of steel G of the same diameter to a length which gave it a slight clearance between the valve in position and the tappet H at its lowest point. We next found a piece of steel tube F which was an easy fit over the tappet, valve stem, and steel piece. This tube we cut to such a length that it inclosed the two former at its extreme ends, holding the steel piece G in position between the two. The only thing now to be done was to find a method of adapting the spring A to the shortened stem of the valve, and we managed this by cutting a screw thread E on the latter, shortening the spring by cutting off the hooked end, and fitting under the spring, when in position, a large washer C, a nut, and a thin lock-nut D. The whole, when complete, was somewhat as shown in Fig. 2. We found it worked perfectly, and that it was of no consequence whether the piece of tube

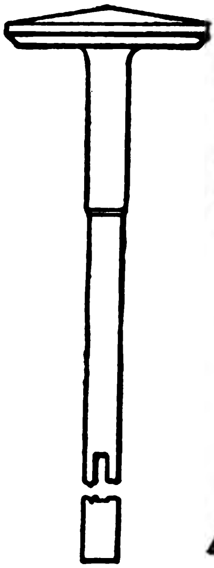


Fig. 1.
The broken exhaust stem.

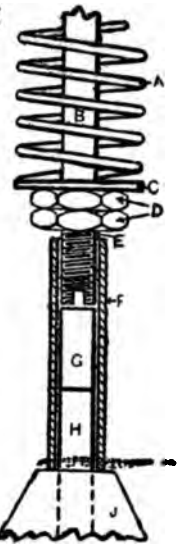


Fig. 2.
The stem repaired.

[illegible] the bottom and find [illegible] did not [illegible] The [illegible] than an hour and [illegible] from home [illegible] found it unnecessary [illegible]

[illegible]

[illegible] would be a very good plan [illegible] al [illegible] of silver [illegible] and the absence [illegible] and send someone [illegible] a piece of [illegible] bring you home [illegible] and anyone [illegible]

[illegible]

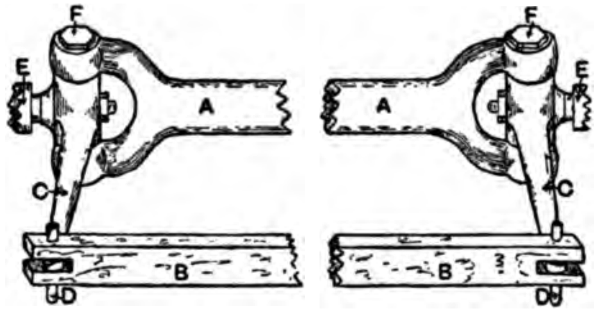
[illegible] with the [illegible] The [illegible] was [illegible]

[illegible]

[illegible] in the previous [illegible] so much that what [illegible] the sackness of the [illegible] it was impossible to [illegible] at the same time have sufficient clearance between the platinum points, when the blade was at rest on the plain portion of the cam. A new one was required, but he had no such spare part with him, and could not obtain one in the town. To wait while the nearest agents sent one would have meant a long delay, so a makeshift was decided upon, and after consultation with a bicycle agent they fixed it up as follows: They first softened the cam and filed off the remains of the "hump"; then they drilled and tapped a 3/16 inch hole at that spot. The end of a piece of ¼ inch silver steel was then filed, and a 3/16 inch screw thread cut on it. This was screwed very tightly into the hole made in the cam—a shoulder was, of course, formed by the small thread on the ¼ inch steel—and burred over the inner end. The portion standing out was filed to the required U shape and the whole rehardened and tempered. Time, half an hour; result, perfect firing and plenty of adjustment.

A Steering Gear Repair.

Another roadside repair enabled an owner to reach home (a matter of thirty miles) without great delay on an occasion when, after running into the back of a wagon, he found



A, ends of front axle.
B, piece of wood used as a temporary distance rod.
C, steering arms.
D, temporary pins.
E, ends of wheel axles.
F, steering center pins.

that the damage consisted of a broken coupling rod in the steering gear; in other words, the rod which connects the two front wheels. The steering arm on the near side was also slightly bent, but the rod had broken off short about 1½

inch from the bolt hole. He fixed up a temporary repair, not troubling to straighten the arm, in the following manner: He removed the rod entirely, and from a cottage near by obtained a piece of wood B B (see illustration), the section of which was about 3 inches square. This he cut off to a length of 3 inches in excess of the distance between the bolt holes on the steering arms with the wheels parallel, making a slot of about 2¼ inches in each end for the arms C C to fit into. Now came the difficulty of making holes through the ends to fit bolts through. A drill and brace were not available, and eventually the owner hit upon the plan of burning two holes with a red-hot poker, which he obtained and heated at the cottage. The bolts he had taken out were, of course, too short to go through 3 inches of wood, and, as he had none on the car of sufficient length, he was compelled to use the best material he had for the purpose. This proved to be the large lever for use with the box spanners. He filed it partly through at the center, broke it in half at that point, and fitted the two pieces D D, one at each end, through the holes in the wood and steering arms, wiring the extemporized bolts in position. He reached home safely, but, as can be imagined, no speed bursts were indulged in, the rate in miles per hour being such as to satisfy the most critical village constable.

Coil Troubles.

An annoying experience which many automobilists have had is to have a trembler break when driving a car fitted with battery ignition and trembler coil or rendered useless in any way, and to find that no spare parts are available. An owner writes that he has surmounted this difficulty on a car with a four-cylinder engine in the following manner: He detached the two wires, one leading from the sparking plug and the other from the commutator, which were in connection with the broken trembler and fixed them to the corresponding terminals of the coil whose firing was set at 180°. That is to say, supposing the engine was so arranged that the cylinders fired in the order 1, 3, 4, 2, and that the trembler of No. 1 coil had broken, he detached the high and low tension wires from No. 1 and fitted them to the terminals of No. 4, leaving in position those which rightly belonged to the latter. The result is that No. 4 trembler works when contact for No. 1 is made at the commutator, in addition to doing so, as usual, when No. 4 is at firing point. It is true that a spark will take place in both cylinders each time that contact is made for either, but this duplicate spark will not have the slightest ill-effect, provided the ignition is not retarded beyond a certain point. To show the reason of this we will continue the hypothesis and imagine that No. 1 cylinder is firing; if the ignition is now set, as it should be for the engine to develop most power, to cause a spark at a time when the piston is nearing the end of the compression stroke, then the duplicate spark takes place in No. 4 cylinder at the end of the exhaust stroke; consequently no harm results. Should, however, the ignition be so retarded as to occasion a spark in No. 1 on the downward or firing stroke a back-fire to the carbureter will probably occur from No. 4 on account of the inlet valve of that cylinder being then open. The use of this makeshift gives rise to a slight difficulty when starting the engine by reason of the comparatively advanced point of ignition, but the necessary advance is really so light that a little extra care will prevent personal injury from a "kick" or back-fire.

This temporary remedy also applies when similar trouble is experienced on a two-cylinder engine with firing points set at 180°. In this case it is merely a matter of fixing the high and low tension wires of the coil with the defective trembler to the corresponding terminals of the other. The necessity of keeping the ignition fairly advanced also applies.

This makeshift has been used as a means of testing one of the coils which was suspected of shorting in the high tension winding, and the resultant perfect firing in all cylinders by means of the other three coils, although such was not the case when also using the fourth, has tended towards confirming suspicions that the latter was defective, or, if it has not assured the owner on this point, has reduced the possible region of trouble very considerably.

A Magneto Tappet Lever Repair.

Another makeshift to which an owner was compelled to resort was in connection with low tension magneto ignition. A total cessation of firing in one cylinder was the notice received that something was at fault. A stop and an inspection ensued, the ignition cut-outs on the top of the engine proving which cylinder was the offender. The springs and exterior movements being quite in order, the inlet valve cap was removed to enable the make-and-break to be seen. The defect was then apparent. The end of the arm of the tappet, where it should have made contact with the plug inside the cylinder, had fractured, but not actually broken off.

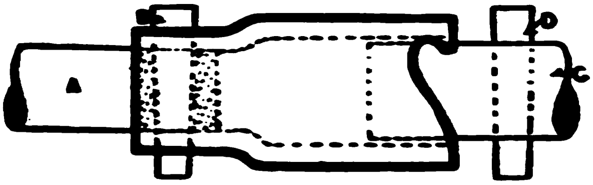
No roadside remedy could be thought of at the moment, so the operator broke off the end of the arm, which was only held by a few grains of metal, to prevent it becoming detached of its own accord and falling on to the piston. He then drove, with three cylinders firing, to a small town some seven or eight miles away, where a temporary repair was made, with help obtained locally, in the following manner: A piece of flat steel, ⅜ inch x 5/32 inch, was cut off to a length of ⅝ inch in excess of the broken portion, and fixed by two rivets to the shortened arm. The hole was then brazed together, and the end set to an angle which would bring the point under the ignition plug. He did not put much faith in the brazing, having doubts as to whether or not the brass would "run" when subjected to the heat of the explosions. The repaired tappet was used, however, with complete satisfaction, though with some anxiety as to how long it would last, until a new one was received on the evening of the following day, and when removed it gave all appearances of remaining intact; the same amount of spelter was visible as when first used, so that, apparently, the heat was not sufficient to melt it.

Repairing an Inlet Valve.

An automatic inlet valve which fractured at the cotter hole, was repaired by the roadside, on one occasion, in a very simple manner. The driver merely shortened the spring, and, with the valve in its seating, fitted a washer over the spring, and burred over the broken end of the valve to keep the washer in position. The engine—a single-cylinder De Dion—pulled quite as well as usual, and he ran that broken valve, occasionally removing it to burr over the top a little more, for some five or six weeks, and even then it worked so well that he hesitated to put in a new one.

Repairing a Starting Handle.

An automobilist was once descending a hill, when a noise was heard which sounded as though some part had become detached, and in falling had struck or rebounded against the crank chamber or gear-box. On looking round he saw something in the road, which, on closer inspection, proved to be the starting handle, or rather a portion of it. The handle was of that type which has a hollow piece of turned steel fitted to the end near the engine, shaped out to "claw" a pin on the front end of the crankshaft, this hollow piece of steel being secured to the handle by means of a thick taper pin. What had happened was this: The taper pin had fallen out and the handle had gradually worked forward, thus allowing the hollow piece to drop. Then, or perhaps some little time after, the handle had fallen out of its bearing. The owner could not find the "claw" piece, although he walked back about two or three hundred yards, and without this he could not restart the engine, for, unfortunately, he had stopped it when pulling up; if he had not done so it would have been an easy matter to have driven to the nearest blacksmith's shop and have obtained a piece of steel to take the place of that he had lost. But having stopped the engine, he had to devise some means of making a temporary starting handle. He first tried the plan of pushing the car when in gear and then letting in the clutch sharply, but there being only the owner and a friend they could not get sufficient "way" on the car to obtain the desired result. The following idea was suggested: There was a set of tube spanners on the car, and that for the smaller nuts was drawn out at one end to a smaller diameter than the body of the spanner. They filed off a length of about two inches at this end and were then possessed of a piece of steel nearly the same shape as that lost, but, of course, much thinner. Having no means of drilling a hole at the drawn end for a pin to pass through, they made two slots, as shown in the figure with a round file. The necessary claws in the large end were also filed to a shape deep enough to answer the purpose temporarily. When fitting the makeshift together they used a bolt and nut instead of a taper pin, and by so doing the whole thing was practically as firm and without likelihood of becoming detached as if a hole had been drilled and a pin used. The filing of the slots at the one end and the "claws" at the other was, naturally, an awkward piece of work, and occupied some time, for the only means at disposal for holding the tube during the process was a small hand vise. This "fake" was sufficiently successful to cause the participants to come to the decision that there was no necessity to obtain anything else in this direction before they arrived home, for the engine was started some fifteen or twenty times by the means they had provided.



Repairing a broken starting handle-shaft.
A, end of starting handle-shaft. C, end of engine crankshaft.
B, taper pin securing steel claw to handle. D, taper starting pin.

Other Difficulties Overcome.

The gas-bag of an acetylene headlight burst on one occasion when the owner had not another with him, nor could he obtain one in a town through which he was passing, so he bought a piece of cycle air tube about five inches in length, and bound the ends very tightly with string to the small brass gas pipes. In the first instance, he used wire instead of string, but found that this cut through the rubber immediately. By "puckering" the ends of the rubber tube neatly before the binding operation, the "fake" was quite a success.

Another experience was that of having tire troubles galore, with the result that all the spare tubes had been put into requisition and all the patches used. The owner therefore had to fall back upon the only rubber then remaining on the car which could be turned to account, viz., his tobacco pouch. With this he patched two holes, and the tubes so repaired retained air for as long a period as the average unvulcanized patch allows.

Lights without Matches.

Many motorists would imagine themselves in evil case if, when ten miles from anywhere, with night coming on, they found themselves without matches when it became necessary to light up. But let them not despair. Their electric ignition system, if it includes batteries will come to their aid. The method of procedure is as follows: Detach one of the high-tension wires from its sparking plug, and attach it to a spare plug, which you will allow to repose upon any convenient part of the frame, so that the high-tension current can ground readily. Now place in the spark gap of the plug a piece of tissue paper, cigarette paper, dry grass, or straw, which has been previously dipped in gasolene. Then switch on and turn the engine round until the high-tension current flows to the plug on the frame, when the spark leaping the gap will fire the gasolene on the paper or other material, and your much-desired fire is obtained. Of course, if you have exterior spark gaps, the igniting trick can be worked there.

Makeshift Steering Gear Repair—See Makeshifts on Tour.

Mandrel—A shaft or spindle supporting or holding any object to be rotated or turned; an arbor.

A mandrel is a cylindrical piece of metal, generally of steel, which can be employed for a variety of purposes in the workshop. It is generally used for the purpose of holding cylindrical objects between lathe centers when turning them. Gear wheels are also mounted upon it in the milling machine when their teeth are being cut. The term "mandrel" is rather a loose one, and is applied to a great number of appliances in the shops.

Manganese—A metal of a dusky white or whitish gray color, very hard and difficult to fuse, and frequently associated with iron. It never occurs as a natural production in a metallic state. The substance usually so called is an oxid of manganese but not pure.

Manganese Bronze—A compound of zinc, copper and a small percentage of manganese, very useful in construction work and a favorite metal for bearings, etc.

Manganese, Ferro—A compound of iron and manganese employed in the manufacture of Bessemer steel.

Manifold—A cylindrical tube having a number of outlets for connecting it to others; a T-branch; used with multi-cylinder engines for inlet pipes, etc.

Manipulating the Control—See under Driving.

Manograph—A device for indicating and registering on a diagram the pressure in the cylinder of a gas engine.

Manometer—A device for indicating the circulation of the water in a radiator. See Water Circulation, under Care and Maintenance; also see Pressure Gauge.

Marine Engine—An engine built especially for propelling a ship or boat.

Marine Gasolene Engines, Advanced Type of—Wonderful development has been made in the past few years in the manufacture of gasolene engines for marine use, as well as in those more particularly designed for motor cars. Each year has brought forth many new improvements in these motors. For example, the Ferro Machine and Foundry Co., of Cleveland, Ohio, whose motors are widely used in power boats, have embodied several important improvements in their latest Ferro engines, described as follows:

"One of these improvements, the offset cylinder, will prove a great factor in prolonging the life of Ferro motors. By making the center of the cylinder deviate from the crankshaft, the crankshaft is in a turning position, not at dead center, on the impulse stroke of the piston. Thus the force of the impulse stroke exerts a turning effort on the crankshaft and the maximum power and efficiency is secured from the motor. Furthermore the side thrust on the cylinder wall is equalized and there is no knock, which always tends towards loosening of parts and premature decay of the motor.

"Another improvement in the 1909 Ferro engine is the counter-balanced crankshaft. Iron weights are placed opposite the crank so as to balance the weight of the crank together with the piston and connecting rod upon it. In this way the piston always has the same weight attached to it, and all possibility of jar or vibration is eliminated.

"A third improvement in this motor is the accessibility of the parts. A hand-hole is placed at the base of the cylinder which when opened permits the entrance of the hand and wrench and also serves to allow a view of the entire interior of the crank case. The cylinder head may also be taken off, so that free access may be had to the interior of the motor for the easy removal of the piston and connecting rod without otherwise disturbing the motor itself. The cylinder head is water-jacketed and connected to the cylinder by a positively tight joint.

"The subject of ignition is one of the most important ones to the owner of a gasolene engine, and the Ferro company have given particular attention to this. Their engines are furnished for either jump spark or make-and-break ignition. The jump spark system is the most efficient where it will not be exposed to moisture or. water. The make-and-break system, however, by virtue of its low tension current is not subject to short circuit or leakage of electricity and water can have no detrimental effect on it. For this reason, the make-

and-break system of ignition is to be advocated where the motor is to be placed in an open boat, such as the utility boat or fisherman's craft.

"Another interesting feature in the construction of these engines is the cooling system. This consists of pumping the water into a hollow chamber surrounding the cylinder and keeping it in constant circulation in this chamber. The water enters at the bottom of the cylinder, the coolest part, and floods the entire jacket, discharging near the top. No matter how hard the engine is run, in polar or tropic regions, day or night, there is always the same ample supply.

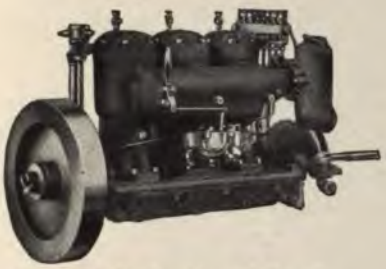
"One of the most important needs of the gasolene engine is that it be properly lubricated. The positive pressure oiling system of the Ferro engine takes nothing for granted and works just as surely as the engine works, forcing a uniform, constant supply of oil to every bearing surface in the exact amount required by each.

"The gasolene engine has unquestionably demonstrated its efficiency for use on work boats. A great many people, however, think that the heavy slow speed engine is the most satisfactory for work boat use. This is not the case. The modern two-cycle type of light-weight high speed engines, such as the Ferro, has easily demonstrated its availability for heavy duty.

"These engines are also fast proving their adaptability for stationary use. It is only reasonable that this should be so, as it is evident that a motor built for marine purposes operates at a speed which is non-varying. For this reason, wherever the load is an even one, the Ferro motor proves satisfactory for stationary use."

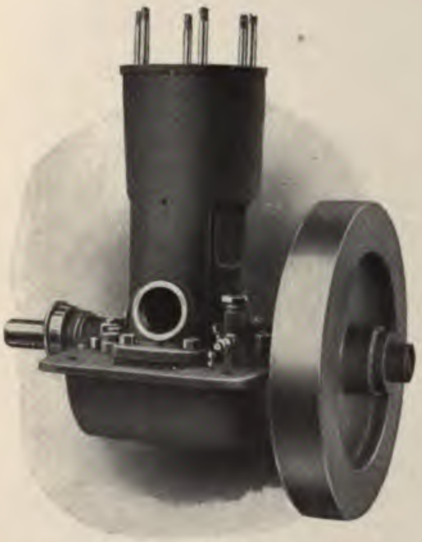
The photographic illustrations of the Ferro engines which appear elsewhere will be found of especial interest to the many automobilists who also own or operate motor boats. "A Practical Treatise on Marine Gasolene Engines," published by the Ferro company, is a valuable contribution to the literature of the subject.

Marine Glue—See under Glue and Cement.

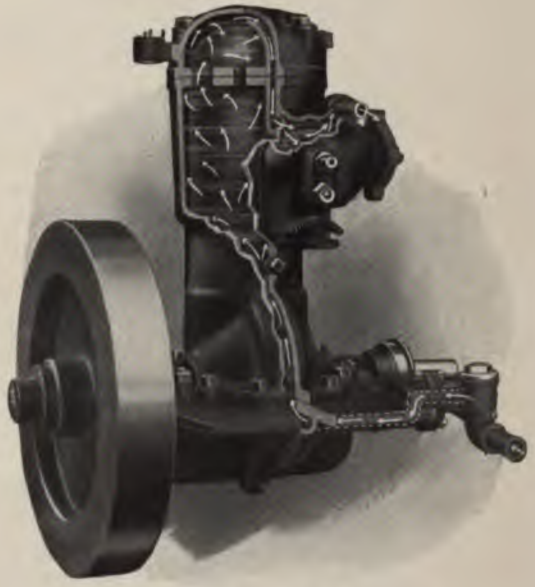


3-Cylinder Ferro Motor.

Large Heavy Cruiser, Equipped With Ferro Motor.



Ferro Motor With Handhole and Cylinder Head Removed.



Water Circulation in Ferro Engine.

Marks for Coil Terminals—See under Ignition.

Marline—A small rope or line composed of two strands slightly twisted and either tarred or white, used for winding round ropes and cables to prevent their being fretted by the blocks, etc.

Marlinespike—An iron tool tapering to a point used to separate the strands of a rope in splicing.

Mass—The sum of all the material particles of a body. The mass of a body is estimated by its weight, whatever be its figure, or whether its bulk or magnitude be great or small. In mechanics, the mass multiplied into the intensity of gravity at the place constitutes the weight of the body. The measure of gravity, which is independent of the particular nature of the body, is the weight of what is arbitrarily assumed to represent the "unit of mass."

Mass, Unit of—In the centimeter-gram-second system the unit of mass is the gram. In the foot-pound-second system the unit of mass is the pound.

Masse—The French word "masse" corresponds to the English "ground" or "earth" in electricity, and its abbreviation "M" is marked at the terminals of French batteries and coils to which the ground wires are to be attached.

Mastic—A resin exuding from a tree of Southern Europe. Dissolved in spirits of wine it is used as a varnish.

Matches, Lights Without—See under Makeshifts on Tour.

Materials—All materials used throughout the construction of high class modern cars are the best quality obtainable, and each part, no matter how small or inconspicuous it may be, is made from material which is the most suitable for the purpose.

The following is a description of the materials used in a well-known and typical high-class car:

"Alloy steel, the best and most expensive grade produced, is used throughout the entire car because it possesses the greatest strength in combination with the greatest elasticity, thus enabling parts to be made not only very much stronger, but very much lighter than from ordinary steel. The pressed steel frame, the backbone of the entire car, is made from alloy steel, heat treated—not from ordinary steel which is commonly selected for the purpose owing to the fact that its cost is only one third of that of alloy steel.

The car springs are also made from this wonderfully tough and resilient material, and this, coupled with the unusually large dimensions of the springs and other details of [illegible] makes it an easy riding car. Alloy steel springs [illegible] exceedingly strong and breakage is rarely, if [illegible] a consideration of great importance. Crankshafts, [illegible] gears, transmission shafts, countershafts, [illegible] gears, steering mechanism and bearings, and other [illegible] alloy steel. The manufacturers' experience [illegible] extends over several seasons and [illegible] handling and heat treating [illegible] the latest and most approved type: all [illegible] heated by crude oil burners and [illegible] electric thermometers), a [illegible] the heat of the furnace to be [illegible] high temperature and maintained in-[illegible]

[illegible]

a fair general knowledge of mechanics is all that is required. A man of the latter class may be engaged for about half the sum that would have to be paid to a fully qualified man. He is generally referred to as the chauffeur in American usage, while the term mechanic or mechanician is restricted to those employed in making or repairing machines.

Mechanical Efficiency—See Horse Power; also Efficiency.

Mechanically-operated Inlet Valve—See Valves.

Mechanics—That branch of science which considers the laws of equilibrium and the motion of solid bodies; the forces by which bodies, whether animate or inanimate, may be made to act upon one another, and the means by which these forces may be increased so as to overcome those which are more powerful. Applied mechanics takes note of the application of the principles of mechanics to practical purposes, as the construction of machines, etc.

Meg-, Mega—Combining forms which, in physics, signify multiplication by a million, as in megohm, megavolt, etc.

Member—Any individual part of a combination, aggregate or whole, as the female member of a screw coupling, etc.

Mercury—Quicksilver, a metal whose specific gravity is greater than that of any except the platinum metals, gold and tungsten, being 13.56, or thirteen and a half times heavier than water. It is the only metal which is liquid at common temperatures. It freezes at 39 or 40 degrees below zero Fahrenheit, and at 660 degrees above it rises in fumes and is gradually converted into red oxid. It is used in barometers, thermometers, and in the extraction of gold and silver from ores in the amalgamation process.

Mesh—In mechanics, the engagement or meshing of the teeth of wheels, as of a pinion and rack. Gear wheels are said to be "in mesh" when their teeth are engaged and they are working properly together. When disengaged, co-ordinate toothed wheels are said to be "out of mesh." See Gear or Gearing.

The term "mesh" is also applied to the threads or wires